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EOLOGICAL SURVEY.

BULLETIN No. 69.

CONTRIBUTIONS

TO THE STUDY OF

THE GEOLOGY AND ORE DEPOSITS OF KALGOORLIE

East Coolgardie Goldfield.

PART III.

BY

F. R. FELDTMANN.

ISSUED UNDER THE AUTHORITY OF
THE HON. R. T. ROBINSON, K.C., M.L.A., MINISTER FOR MINES.

WITH 14 PLATES AND 43 FIGURES.

PERTH:
BY AUTHORITY: FRED. WM. SIMPSON, GOVERNMENT PRINTER.

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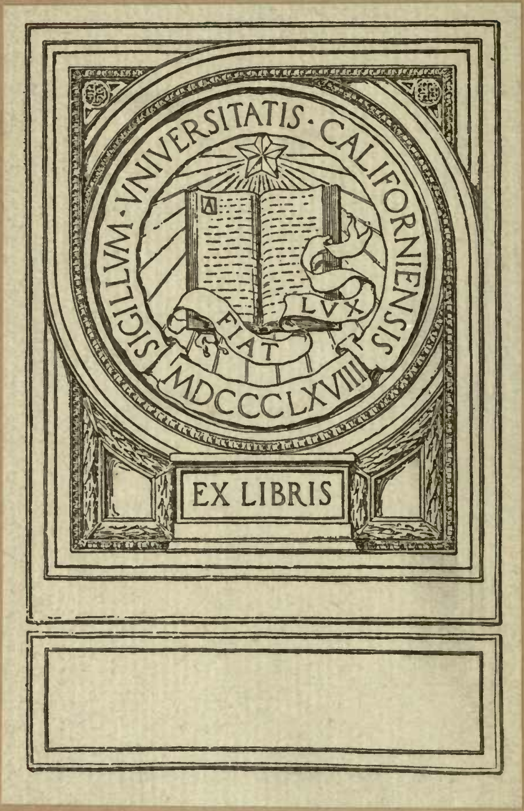

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WESTERN AUSTRALIA.

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PREFATORY NOTE.

The present contribution forms the third of the series designed to deal more or less exhaustively with the Geology and Ore Deposits of Kalgoorlie.

It had been intended to include in this *Bulletin* the contribution by the Petrologist, Mr. Farquharson, but as such was not available at the time this was ready for Press it was not deemed expedient to delay the publication of the information regarding the ore bodies and mines of the North End. The petrological contribution will, it is hoped, appear later.

A. Gibb Maitland

GOVERNMENT GEOLOGIST.

Geological Survey Office,
Perth, 1st August, 1916.

697859

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* Serving with the Expeditionary Forces.

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Contributions to the Study of
The Geology and Ore Deposits of Kalgoorlie,
East Coolgardie Goldfield.

PART III.

X.—THE GEOLOGICAL FEATURES OF THE "NORTH END," KALGOORLIE.

By F. R. FELDTMANN.

AUTHOR'S NOTE.

The writer takes this opportunity of acknowledging his indebtedness to Mr. Farquharson, on whose determinations the rock-classification adopted in this report has been mainly based, and whose friendly criticism on many points has proved of very great assistance.—F.R.F., 5th July, 1916.

INTRODUCTORY REMARKS.

The portion of the Kalgoorlie auriferous belt with which the present report is most chiefly concerned is that to the south of the area described by the writer in Bulletin 51,* and is roughly bounded on the north-west by the Kanowna Railway line, on the south-west by the Boulder Railway line, on the north-east by a line roughly parallel to and about 70 chains from the last, and on the south-east by the southern limit of the flat south of Mt. Gledden, this flat seeming to form the natural boundary between the "North End" and the main auriferous belt of Kalgoorlie.

The area between these boundaries has been mapped on a scale of 100 feet to the inch (Plate XIII.), permitting all the important geological features, including the ore deposits, to be shown in detail. In addition to this detailed map, one on a scale of 10 chains to the inch (Plate XII.), covering an area of about five square miles, has been prepared. This map shows, in addition to the main geological features—including the main lines of lode— contour lines at 10-feet intervals; as the railway bench-marks are the datum points on which these contours are based, a reduction of 107 feet has to be made to give the true height above sea-level. For this map, the contours shown on the map published by the Survey in 1902 have been thoroughly revised, while that portion south of the Kanowna Railway line, which has been mapped on a scale of 100 feet, has been recontoured, owing to the extreme accuracy required for the geological sections, prepared on scales of 100 feet, 50 feet, or even less, to the inch.

---

* Contributions to the Study of the Geology and Ore Deposits of Kalgoorlie, Part II. by F. R. Feldtmann and R. A. Farquharson.

I would here like to record my thanks to the leaseholders and prospectors of the North End, without whose ready assistance, often at considerable personal inconvenience, I should not have been able to examine many of the mine workings within this area.

I. TOPOGRAPHY.

The main topographical features of the more southerly portion of the North End differ but little from those of the more northerly portion. On the whole the hills are more decided in outline and rise to a greater relative height above the surrounding country.

A prominent feature is the well-marked line of hills comprising Mt. Charlotte, Hannan's Hill, Cassidy Hill, and Mt. Gledden, immediately to the east of the Boulder Railway line and following the general N.N.W.-S.S.E. trend of the country. Unlike the higher hills of the northern area, these hills, which are almost entirely in quartz-dolerite greenstone, are not capped by laterite, which is by no means as common in this as in the previously described area. This fact may probably be accounted for by the steeper slope of the hills and the consequent greater rate of denudation.

II. THE ROCKS.

In the previous report* the writer considered it more than likely that the more southerly portion of the field would throw further light on the geology of the northern portion—this belief has been amply justified, the more numerous outcrops, extensive mine workings, and comparative freshness of many of the rocks enabling a more thorough and detailed classification to be made than was possible in the earlier report. Nevertheless, as compared with the great variety of the rocks, exposures in outcrops and mine workings are by no means as common as could be desired, particularly in the low-lying ground on which the town itself is situated, unweathered outcrops and mine-workings sufficiently deep to be of any use being here practically absent.

---

* *Loc. cit.*, p. 10.

In the light of data now available the northern area was briefly re-examined and its rocks reclassified, the results being shown on the 10-chain map (Plate XII.), but the mapping of the ore deposits and other details shown on the 100-feet map is not affected by this revision. The detailed description of the rocks given in the following pages applies to the North End as a whole.

The present classification is based on the results of a detailed and thorough examination of the relationships of the rocks in the field, as well as the petrological examination by Mr. Farquharson of over 200 specimens collected by the writer, and also of many of those already in the Survey collection. In addition a number of fresh analyses have been made by Mr. E. S. Simpson, Mr. H. Bowley, and other members of the Laboratory Staff.

The present classification differs from that given in Bulletin 51 chiefly in the separation of the Older Greenstone series from the Younger or Intrusive series—which, owing to the paucity of exposures and lack of any marked differences in the specimens previously examined, was not possible when dealing with the more northerly area alone. Both Older and Younger Greenstones have been further separated into groups and sub-groups, many of which are unrepresented in the northern area.

The classification now adopted may be subject to criticism on account of its extreme detail, but it is justified by its exceedingly important economic bearing. In general it approaches most nearly to that given in Dr. J. A. Thomson's paper.*

---

*. "The Petrology of the Kalgoorlie Goldfield." Quart. Journ. Geol. Soc., Vol. xix., 1913, page 626.

ROCKS OF THE "NORTH END."

Original Rocks.		Present Form of Rocks.
1. Lavas (Older Greenstones) ..	Lavas	(*a*) Fine-grained amphibolites [epidiorites (*b*)]. (*b*) Fine-grained greenstones. (*c*) Calc-schists.
2. Intrusives— A. Basic to ultrabasic (Younger Greenstones)	Quartz-gabbros or quartz-dolerites	(*a*) Amphibolites [epidiorites (*a*)]. (*b*) Greenstones. (*c*) Bleached greenstones. (*d*) Actinolite-zoisite amphibolites [epidiorites (*b*)] in part.
	Gabbros or dolerites	(*d*) Actinolite-zoisite amphibolites [epidiorites (*b*)] in part. (*e*) Greenstones.
	Hornblende-dolerites	(*f*) Lustre-mottled amphibolites.
	Pyroxenites	(*g*) Hornblendites. (*h*) Talc-chlorite-carbonate rocks.
	Peridotites	(*i*) Talc-mesitite rocks. (*j*) Serpentines.
	? (Various)	(*k*) Fuchsite-carbonate-quartz rocks.

ROCKS OF THE "NORTH END"—*continued.*

Original Rocks.		Present Form of Rocks.
B. Intermediate to acid	Hornblende-quartz-porphyrites	Hornblende-quartz-porphyrites.
	Albite-porphyrites	Albite-porphyrites.
3. Sediments	Sediments	Slaty beds.
4. Superficial deposits		(*a*) Laterite. (*b*) Sand, loam, etc.
5. (Various)		Jaspers and graphitic schists.

In the above classification and in the following pages the term greenstone is used in two ways: first in the usual broad sense as applied to the two main series of basic rocks—viz., the Older and the Younger or Intrusive Greenstones—when used in this sense a capital letter is employed; secondly as restricted by Thomson* to those rocks composed chiefly of chlorite and carbonates in place of the hornblende and saussurite of the amphibolites, as, for example, the quartz-dolerite greenstones. There should be no confusion between these two applications of the term.

It will also be noticed that the name epidiorite figures in the classification as an alternative name for some of the amphibolites. Some confusion seems to have arisen in the employment of the former term. The best classification of the epidiorites is that given in Teall's description of the geological structure of the North-West Highlands of Scotland.† Here he says:

> ''They'' (the epidiorites) ''may be roughly separated into two groups according to the presence or absence of the structure characteristic of the gabbros, diabases, and hyperites. In the first group (a) the lath-shaped or interstitial character of the felspar-sections is in most cases well marked, and the characteristic inclusions so common in the felspars of the diabases are often present. The hornblende is of two types. There is the compact green hornblende, similar to that of the hornblende-diabases, and also the fine-grained and sometimes fibrous aggregates which appear to eat into and finally destroy the original augite. Cores of augite may frequently be detected in the centres of these hornblende-aggregates, a little interstitial quartz is often present. . . . . The typical rocks of the second group (b) of epidiorites are devoid of igneous structure. They are essentially composed of plagioclase and hornblende, with which some quartz and a mineral of the epidote group are often associated. The felspar occurs as irregular grains or in large ophitic patches; sometimes as granular aggregates. It is in general more allied to albite than the felspar of the pyroxenic rocks. Not unfrequently it is crowded with minute prisms and grains of epidote, thus forming the typical saussurite of Cathrein. Under these circumstances it is either albite or some closely allied felspar. The hornblende may be either pale or dark green. It occurs as spongy aggregates enclosing rounded grains of quartz, as compact irregular individuals, and as aggregates with ragged outlines from which prisms often jut out into the surrounding felspar. Detached grains and prisms often occur as inclusions in the felspar. Biotite and iron-ores zoned with colourless granular sphene are frequently present.''

In the classification of the North End rocks the epidiorites fall into two groups, (a) and (b), as classified by Teall.

In order that the relationships between the various subdivisions of the Older Greenstones and the gabbroid or doleritic members of the Younger Greenstones, and the successive degrees of alteration, may be more clearly understood, it may be advisable to present a portion of the classification in the following form:—

---

* *Loc. cit.*, p. 630.

† Memoirs of the Geol. Surv. of Great Britain, 1907, p. 92.

Original Rocks ..	Lavas	Quartz-gabbros or Quartz-dolerites	Gabbros or Dolerites	Hornblende-dolerites.	Pyroxenites.
Amphibolitic Stage	Fine-grained amphibolites	Quartz-dolerite amphibolites	(Unrepresented in this area)	Lustre-mottled amphibolites	Hornblendites
Greenstone Stage..	Fine-grained greenstones	Quartz-dolerite greenstones	Dolerite greenstones	(Unrepresented)	Talc-chlorite-carbonate rocks
Bleached Stage ..	Calc-schists	Bleached greenstones	Fuchsite-carbonate-quartz rocks (in part)	(Unrepresented)	Fuchsite-carbonate-quartz rocks (in part)

A parallel series of changes has taken place in the peridotites, for we have serpentines, talc-mesitite rocks with, probably, some of the fuchsite-carbonate-quartz rocks as the third stage of alteration.

This grouping according to the various stages of alteration does not necessarily imply that the more altered rocks have passed through all the intermediate stages, for it is possible that some of the greenstones may have been derived directly from the original rocks without passing through the amphibolitic stage. This question, however, will be gone into more thoroughly later on.

When describing each rock type in detail it will be stated whether, or no, the rock is of economic importance—this statement refers only to the occurrence or non-occurrence of payable deposits in the rock and not to the part it may have played in the introduction of the auriferous solutions.

1. The Older Greenstones.

Within the limits of the 10-chain map (Plate XII.) the rocks of this series occupy two large areas, namely, to the west and east of the main dyke of Intrusive Greenstone described later. The full extent of the western area has not been mapped—its eastern boundary appears to run roughly parallel to and about seven chains east of the Menzies Railway line; it is probably composed entirely of fine-grained amphibolites. Under the townsite of Kalgoorlie it is entirely obscured by superficial deposits and its southern extension could not be traced—specimens occur on the dump of the former Red Hill Extended (G.M.L. 64E) main shaft, but whether this occurrence represents an isolated area or part of the main western belt it is impossible to say. These rocks certainly do not form the wide continuous belt shown on Mr. Gibson's map,* for close examination has shown the presence of outcrops of quartz-dolerite amphibolite, actinolite-zoisite-amphibolite, and quartz-dolerite greenstone at the corner of Harley and Hinemoa Streets, west of Mullingar. Moreover petrological determination of the municipal quarry rock at Mullingar shows it to be a dolerite-greenstone and not one of the Older Greenstones.

---

* Contributions to the Study of the Geology and Ore Deposits of Kalgoorlie, Part I., by E. S. Simpson and C. G. Gibson. G.S.W.A., Bulletin No. 42, Plate II.

The eastern belt is of great width, averaging probably between 60 and 70 chains; it also is largely obscured by superficial deposits. The northern portion of this belt appears to consist entirely of fine-grained amphibolites, which pass gradually into fine-grained greenstones to the south.

Unweathered outcrops are not common in either of these two belts, and the fine-grained amphibolites are exposed only on a few, usually weathered, dumps in addition to the very meagre outcrops. The fine-grained greenstones are fairly well exposed on dumps and to some extent in mine workings in the south-eastern portion of the area. The calc-schists are but poorly represented in this area, occurring only as local modifications of the fine-grained greenstones; they reach a very much greater development on the "Golden Mile."

The original form of the Older Greenstones is obscure, owing to the absence of relict-structures. In the majority of cases these rocks are exceedingly fine in grain, of intermediate-basic composition in those specimens which have been analysed, being apparently slightly more acid in composition than the quartz-dolerite derivatives, and in a few instances present the appearance of a fine-grained flow dolerite under the microscope. As Thomson states,* it would be possible to consider them as the altered chilled margins of the Intrusive Greenstones, were it not for their great extent, for it is almost impossible to distinguish between some of the fine-grained amphibolites and certain altered forms of the Intrusive Greenstones. On the bulk of the evidence it seems most probable that they represent original flow lavas; in the specimens examined no evidence was found of an original tufaceous rock.

(a) *The Fine-Grained Amphibolites.*

As already stated, within the limits of the 10-chain map, these rocks appear to occupy the whole of the western belt, and the northern and slightly larger half of the eastern belt of Older Greenstones. On the evidence of isolated dumps, the eastern boundary of the western belt runs through M.H.L. 83E, at the north-west corner of the map, southwards through M.H.L. 200E, to pass close to the eastern boundary of the former Monte Carlo G.M.L. 1249E. South of this it cannot be traced, but, as previously stated, specimens were found on the former Red Hill Ex. dump, west of Cassidy Hill and the Boulder Railway line. Still further south, and beyond the limits of the map, typical specimens occur on a dump near the north corner of G.M.L. 4370E (formerly part of G.M.L. 942E, Queen of the West), near the Boulder Road, and 11 chains west of Kallaroo Station. These rocks do not appear to extend further south for any great distance.

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* *Loc. cit.*, p. 631.

The western boundary of the eastern belt is obscured near the northern limit of the map. It probably crosses the Broad Arrow Road near the North corner of the former Sir John G.M.L. 4468E, to follow the north-eastern boundary of that lease fairly closely and cross the Kanowna Railway line about two chains east of the western corner of the North Collier; thence it crosses the Transcontinental Railway line rather more than a chain east of the north-eastern boundary of the old Devon Consols mine and runs on through the North End Ex. G.M.L. 4485E. Near the southern boundary of the last-named lease a tongue of fine-grained greenstone appears to run northwards through the amphibolite, of which it is evidently an altered portion, to a point about three and a half chains west of the western corner of former G.M.L. 4490E, Colleen Bawn; thence the amphibolite runs southward east of the greenstone tongue to a point a little to the south of the Parkestown Road, specimens being obtained from two dumps between this and the Bulong Road; none, however, were found south of the latter, and apparently the northern boundary of the fine-grained greenstone runs between the two roads; it is, however, entirely obscured, and since the latter rock is regarded as an altered form of the amphibolite, the change is probably very gradual, and the position of the boundary line between the two rocks would, in any case, be largely arbitrary.

The eastern boundary of this belt probably runs about eight chains west of H.L. 176E, near the north-east corner of the map; thence it runs south to cross the Kanowna Road about three chains east of the east corner of M.H.L. 202E and pass through the old "Phœnix" brick pits, where the junction of these rocks with the probable sedimentary beds can be seen; unfortunately, both rocks are completely weathered.

Except in the Transcontinental Railway cutting, where both rocks are highly weathered, the junction between the fine-grained amphibolites and the Younger Greenstones is nowhere visible, and the relationship between them cannot be determined in the field.

On dumps in the former Monte Carlo and Queen of the West leases, where the freshest forms of the fine-grained amphibolites occur, derivatives of the quartz-dolerites are also found, and, were these shafts accessible, some light might be thrown on the relationship between these rocks.

The fine-grained amphibolites are found to vary with different localities, but may be grouped into two main types:—The first is a very fine-grained, dense, hard, massive, greenish-grey rock showing in section small lath-shaped felspar forms, now largely saussuritised, in a confused fibrous mass of pale hornblende; minute grains of zoisite occur all over the slide. The Queen of the West rock [**11033**] has a distinctly doleritic appearance in section, and has probably been derived from a fine-grained basaltic dolerite.* The Monte Carlo [**2950**] and Red Hill Extended rocks are of very similar appearance both in the hand specimen and in section.

The second type is similar in colour to, but coarser in grain than the first type, and long needles of actinolitic hornblende can be seen by the naked eye; both in the hand specimen and in section it closely resembles the actinolite-zoisite amphibolites derived from some of the doleritic members of the Younger Greenstones, while some of the coarser varieties are, at first sight, not unlike some of the quartz-dolerite amphibolites in the hand specimen. The lath-shaped felspars characteristic of the first type are absent from this type, in which the confused structure is more apparent, and which is seen in section to consist of long thin needles of actinolitic hornblende in a fine-grained mass of epidote and zoisite. This type is commoner in the eastern belt, typical specimens being found east of the former Sir John G.M.L. 4468E and on the North End Extended G.M.L. 4485E. In the western belt specimens of this type were obtained from a dump near the southern end of the golf links and about 5 chains west of the Menzies railway line. In some varieties of this type there is a development of numerous pale yellowish chloritic, apparently phenocrystal forms; specimens containing these were obtained from an outcrop and shaft about 35 chains west of the Menzies Railway line opposite M.H.L. 200E, and also in the eastern belt from a costeen 5 chains north of the west corner of G.M.L. 4037E.

Of striking appearance is a variety common to both types, in which there is a development of numerous pale spheroids of varying size, but usually about a quarter-inch in diameter, which show up strongly against the darker body of the rock. These spheroids, like the main mass of the rock, are composed of hornblende and zoisite, but with the latter present in far greater proportion. One of the best examples was found on a dump about 110 feet west of the eastern boundary of the Rising Sun G.M.L. 4039E, between the Parkestown and Bulong roads. Less well marked spheroids are also found in specimens from the dump of the previously mentioned shaft west of the Menzies Railway and M.H.L. 200E. The origin of this spheroidal structure which is also developed in some of the fine-grained greenstones is not certain, but it is probably due to contact alteration, being found practically within a belt about 5 chains in width along the eastern boundary of the younger greenstones.

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*The microscopical features of these and other rock types are from determinations by Mr. R. A. Farquharson, Petrologist to the Survey.

Only one analysis has so far been made of a fine-grained amphibolite, namely the Queen of the West rock (Table II., No. 1). The silica percentage is seen to be higher in this rock than in any member of the younger greenstones with the exception of the actinolite-zoisite amphibolites, being higher even than in the quartz-dolerite amphibolites; while the percentage of lime is somewhat lower than in those rocks. It is, however, unsafe to generalise too much on the analysis of one specimen only.

No ore deposits of any importance have been found in these rocks, and from an economic point of view they may be disregarded. It should be mentioned that on the maps the country rock of the North Collier mine, in which a rich "pipe" of ore was found associated with a body of jasper (*vide* Bul. 51, pp. 48/9), is shown as fine-grained amphibolite. There is, however, a small local development of the corresponding greenstone in the vicinity of the ore body.

(b) *The Fine-Grained Greenstones.*

By the formation of chlorite and carbonates in place of the hornblende, zoisite, epidote, etc., the fine-grained amphibolites pass into the fine-grained greenstones, various intermediate stages being found.

Both Gibson and Maclaren group these rocks and the next group together under the title of "calc-schists," but since the type rocks of each are quite distinct, although there is every gradation between them, the writer has adopted Thomson's classification into two groups corresponding to subdivisions of the Intrusive Greenstones.

These rocks occupy the more southerly portion of the eastern belt of the Older Greenstones. Owing to the greater number of mine workings in them, their western boundary, with the exception of that portion immediately south of Williamstown, can be mapped with a greater degree of certainty than that of the corresponding amphibolites; its exact position in the Westralia United mine (former North End mine) is not certain, the rock on the eastern side of the lode channel being too highly altered to permit of definite determination, but from the presence of well-marked spheroids in places in the oxidised zone it probably forms the eastern wall of the southern portion of the lode, the northern portion being entirely in the previously-mentioned tongue of fine-grained greenstone. The junction between these rocks and the quartz-dolerite derivatives has been cut in workings in the Fair Play Extended immediately north of the Bulong road, also in the former G.M.Ls. 547E, Creswick, and 4259E, Conundrum, but in each case the rocks were too highly weathered to determine the relationship between them. There appears, however, to be a development of considerable jointing and possibly faulting in the fine-grained greenstone.

These rocks vary greatly in the hand specimen, but all are fine in grain and of a greenish-grey colour, usually somewhat paler than the corresponding amphibolites; they not infrequently show white veinlets of carbonate. Though usually massive they are often schistose, particularly in the vicinity of the lodes, and show considerable jointing and sometimes brecciation, having evidently been subjected to severe dynamic action (*vide* Fig. 42 and Plate IV.) All are composed of varying proportions of carbonates and chlorite, while sericite and rutile are common, in addition to pyrite and other iron ores; there is usually a total absence of original structure. The massive rock is best seen in workings from the Creswick main shaft [13744]; in the Brown Hill Junction the rock is more schistose. Very interesting specimens were obtained by Mr. W. D. Campbell from the lower levels of the latter mine, now, unfortunately, inaccessible. Some of these show intense shearing and brecciation and a curious development of large white ovoid areas of calcite, up to 1½ inches in length by 1 inch in depth [2827]. Another very interesting specimen [2828] shows numerous small white spherules of carbonate in a dark greenish-grey groundmass and has the appearance of having been an amygdaloidal basalt. A spheroidal or ellipsoidal variety similar to that of the fine-grained amphibolites is common, good examples occurring in the Brown Hill Junction and on the dump of a shaft near the south-west corner of M.L. 104E. As in the amphibolites the spheroids contain the same minerals as the groundmass, *i.e.,* chiefly carbonates and chlorite, with the carbonate in greater proportion; the spheroids are frequently arranged in lenticular patches. In the schistose varieties the spheroids, or, in this case, ellipsoids, are elongated parallel to the planes of schistosity, showing that shearing has taken place subequent to their formation. The spheroidal varieties are found in a belt forming the southerly extension of the belt of the spheroidal varieties of the amphibolites, but more detailed examination shows that they occur mainly along the contact with the Fair Play Extended—Creswick—A.W.A United band of quartz-dolerite derivatives rather than at the contact with the ultrabasic rocks as stated by Thomson.*

In chemical composition the fine-grained greenstones (Table II., Nos. 2 and 3) closely resemble the fine-grained amphibolites, the main difference being, as one would expect, in the percentage of CO_2 present.

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* *Loc. cit.*, p. 634.

The fine-grained greenstones and calc-schists are regarded by Dr. Maclaren as being normally barren, the occurrence of important ore-bodies therein being, he considers, due to auriferous solutions having travelled from the quartz-dolerite dyke to which these ore-bodies are in fairly close proximity. Mr. Gibson* states that "in economic importance the calc-schists probably rank next to the quartz-diabases" (the Golden Mile type of quartz-dolerite greenstone), "many auriferous deposits of considerable importance occurring within them. These, however, have, so far, always been at no great distance from the newer intrusives." Mr. Gibson does not, however, state what conclusions he draws from this fact.

Amongst the ore-bodies occurring in these rocks at the North End may be mentioned the North End Mine's main lode—partly in fine grained greenstone, partly at its contact with the Younger Greenstones; two parallel lodes in the Isabel G.M.L., the eastern ore bodies of the Creswick and those of the Brown Hill Junction and the Mt. Ferrum Consols. It will be noticed that these are all situated near the contact with the quartz-dolerite derivatives, and, moreover, all or nearly all, connect with a narrow and very persistent formation, to be described later, which runs through the Isabel, Creswick and A.W.A. United leases, and which follows the junction of the two rocks fairly closely. This evidence would seem to bear out Dr. Maclaren's views, but more will be said on this point later. Other than those already mentioned, but few lodes occur in the fine-grained greenstones, and these rocks seem to be of little economic importance except near their junction with the Younger Greenstones. Although rich patches occur, usually under special circumstances, the lodes in these rocks are generally poorer and more patchy than those in the Younger Greenstones.

(c) *The Calc-Schists.*

By the development of pyrite and additional carbonates, sericite and quartz at the expense of the chlorite, the fine-grained greenstones pass into the calc-schists.

These rocks, which, as previously mentioned, occur within this area only as local modifications of the preceding group in the vicinity of the local formations, are pale grey or greenish-grey in colour, frequently blotchy in appearance, very fine in grain, and show frequent veinlets of calcite. Though generally massive in "The Mile," in this area the schistose varieties predominate. The best specimens obtained by the writer were from the former Mt. Ferrum Consols G.M.L. 4230E, near the hanging wall of the lode [13776]. In section, they are seen to be composed chiefly of very finely granular carbonates, sericite, and some quartz, rutile is commonly present and small grains of pyrite are frequently distributed through the rock.

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* *Loc. cit.*, p. 18.

2. A.—THE INTRUSIVE OR YOUNGER GREENSTONES.

The rocks of this series occur within this area as a large dyke-like mass with a general strike of rather less than 30 degrees west of north and apparently intrusive into the Older Greenstones. This dyke extends beyond the limits of the map, both to the north and to the south; northwards its full extent is unknown, southwards it extends beyond the Golden Mile. Within this area it reaches its greatest width of rather more than a mile, near the middle of the map—its full extent to the west of Mullingar being, however, hidden by superficial deposits. It narrows considerably to the north, being little more than 30 chains in width as it passes beyond the limits of the map. At the southern end of the map, the western boundary is again obscured, but the dyke seems to have narrowed to a width of about half-a-mile; it widens again as it approaches The Mile.

One other occurrence of the Younger Greenstones was observed within this area, specimens of quartz-dolerite amphibolite being obtained from a dump on M.L. 105E, north of the Bulong Road. This occurrence may represent the northern end of Dr. Maclaren's Brownhill branch, or form part of another smaller branch. It was not seen *in situ*—the shaft being inaccessible—and is, therefore, not shown on the map.

Although the western boundary of the main dyke is completely obscured, in places, at any rate, it extends considerably further west than shown on Mr. Gibson's map.* The eastern boundary, adjoining the eastern belt of Older Greenstone can be followed comparatively closely, though doubtful at some points owing to the similarity between some altered forms of the quartz-dolerites and dolerites and the fine-grained amphibolites; on the whole it, too, runs somewhat further west than shown by Gibson.

The Younger Greenstones vary from basic to ultra-basic, viz., from derivatives of quartz-dolerite or quartz-gabbro to probable peridotite derivatives. The change from one type to another appears to be gradual, and, in consequence, the positions of boundary lines between the different members of the series is, to some extent, arbitrary. From their general occurrence in the field, the different members of this series appear to have been intruded as one mass, different portions of which varied greatly in composition, rather than as a series of separate dykes, with an interval of time between each. This question will be gone into more fully on a later page. On the whole, in this portion of the field, the western half of the dyke is less basic than the eastern, although small areas of quartz-dolerite derivatives occur along its eastern margin.

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* *Loc. cit.*, Plate II.

(a) *The Quartz-Dolerite Amphibolites* [*Epidiorites* (a)].

The main area of these rocks is a belt of greatly varying width, usually occupying the westernmost portion of the main dyke, but extending over its full width at the southern end of the map. splitting into two branches at the southern end of Mt. Gledden. The western branch runs northwards through the western portion of the Cassidy Hill—where it is about five chains in width—Hannan's Reward and Mt. Charlotte leases; thence through Mullingar—where it reaches its greatest width of about 25 chains—gradually narrowing, to apparently tail out to the west of the Hannans North No. 2, the quartz-dolerite greenstone spreading across to the western edge of the dyke; a deposit of laterite, however, obscures the rocks at this point. North of the former Monte Carlo lease, the quartz-dolerite amphibolite is again in evidence, being exposed on a few dumps about 20 chains north of M.H.L. 83E and beyond the limits of the map; its boundaries, however, are entirely hidden. The eastern branch runs between the eastern slope of Mt. Gledden and the western boundary of Williamstown, apparently ending before it reaches the main road leading to Bulong and Parkestown. Another small area occurs to the north along the same line, on the northern slope of Mt. Charlotte; and small areas of this rock occupy the eastern margin of the main dyke along the western boundary of the Isabel and in the western portions of the Euclid and Devon Consols South Ex. leases; while, as already mentioned, a small outcrop occurs near the corner of Harley and Hinemoa Streets, and, finally, there is the occurrence of specimens of this rock on a dump on M.H.L. 105E.

Although some varieties of particularly coarse grain show traces of a gabbroid structure in section, in by far the greater number the remains of structure shown are of an ophitic character, and the original rock was, in the main, undoubtedly a quartz-dolerite, merging into a quartz-gabbro in places.

As oxidation has seldom reached any great depth in the rocks of this group, outcrops are fairly common.

The type rock, corresponding to Thomson's "epidiorites with micropegmatite" and Gibson's "felspathic amphibolites," is exposed in outcrops at the back of the Warden's Residence, in Wordsworth Street, east of the Mullingar Quarry, on a dump on the Gem G.M.L. 4331E, and also on outcrops on the western slope of Mt. Charlotte and on the Hannans Find G.M.L. 4470E. In the hand specimen these are fairly fresh, medium coarse-grained, massive, hard, fairly tough rocks, showing crystals of dark green hornblende scattered in a white, felspathic ground, giving the rock a speckled appearance; to the naked eye, the two minerals appear to be present in fairly equal proportions, varying slightly in different localities. In section these rocks are seen to consist of uralitic hornblende, columnar crystals of plagioclase felspar—usually saussuritised—with some interstitial quartz, and micropegmatite is frequently, but not always, present; apatite is common; original ilmenite is now largely replaced by leucoxene. (For analysis, *vide* Table II., No. 4.)

The rock from the eastern margin of the main dyke, as represented by specimens from the Euclid shaft [**12740**], is very similar to the above, but the original ferro-magnesian mineral is now largely represented by chlorite, while a fair amount of carbonate is present in addition to saussurite, and there is much leucoxene, the rock generally showing an intermediate stage between the amphibolites and the greenstones. Fair-sized areas of granular epidote were present in fragments of quartz on the dump.

A very coarse pegmatitic variety of the quartz-dolerite amphibolite is found on a dump near the centre of the former Eaglehawk United G.M.L. 3770E, at the foot of the western slope of Mt. Gledden. Specimens from the dump [**12937**] show a dark green rock with large platy crystals of hornblende, usually about half an inch in length. Thomson's* mentions one measuring four cms. in length by one cm. in breadth and two mm. in thickness; though usually flat, the hornblende plates are frequently curved to resemble the section of a barrel. In section the rock resembles the more normal amphibolites, but a good deal of chlorite and carbonates are present and the structure is less markedly ophitic. The rock is associated on the dump with more numerous fragments of a rock [**12938**], resembling those of the normal type, but finer in grain, and with the ferro-magnesian present in greater proportion. Both varieties are frequently found in the one specimen.

The coarser gabbroid variety occurs in various localities, notably on a dump on the northern slope of Mt. Charlotte [**13814**], also on a dump about half way along the road from Williamstown to the corresponding station on the Brown Hill Railway line, and east of G.M.L. 4470E [**12935**]. A specimen [**13419**] with gabbroid affinities was also obtained from the dump of the Hannans Hill water shaft. These rocks are not greatly dissimilar to the Warden's residence type, but the ferro-magnesian is present in greater proportion, and in section large interstitial quartz plates and exceptionally large rods of apatite are seen, and the structure approaches the gabbroid.

But few lode formations occur in the quartz-dolerite amphibolites, and these are extremely low in grade. Such occur on former G.M.L. 4470E, Hannan's Find, and on G.M.L. 4524E, on the north-east slope of the Mullingar Hill. Some cross veins of quartz

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***Loc. cit.*, p. 646.

extend from the greenstones into these amphibolites, but they are seldom payable below the limit of the oxidised zone, which in these rocks is usually not far from the surface. In the Kalgoorlie district, therefore, these rocks are practically of no economic importance, although in other districts where the ore-bodies occur as reefs rather than lode-formations payable deposits are found therein.

(b) *The Quartz-Dolerite Greenstones.*

The passage of the quartz-dolerite amphibolites into the corresponding greenstones can be traced through intermediate varieties.

The main belt of these rocks starts at the southern end of Mt. Gledden and runs northwards through Cassidy Hill, Hannan's Hill and Mt. Charlotte; thence across the Kanowna Railway line and through the Napoleon, Golden Zone and Ineeda leases, apparently tailing out in the vicinity of the old Monte Carlo.

Another small belt starts near the southern end of Williamstown and runs north past the south-west corner of the Isabel to join the small area of quartz-dolerite amphibolite east of the Fair Play. A third area of these rocks is found crossing Hinemoa Street, west of Mullingar, but its northerly and southerly extensions could not be traced.

In this area these are usually dull greenish grey rocks from medium to fairly fine in grain, being usually somewhat finer-grained than the preceding group, from which, owing to their indefinite appearance in the hand specimen they are easily distinguished. Though usually massive, schistose varieties occur. Small, pale purplish patches of leucoxene are frequently distinguishable in the hand specimen, and in the coarser varieties outlines of former felspars are sometimes visible. In section they are seen to consist largely of granular carbonate, together with chlorite, much quartz, and a pronounced development of leucoxene and micropegmatite. Varieties in which there is a large development of tourmaline are found in the Mt. Charlotte G.M.L. 211E [**13472** and **13468**].

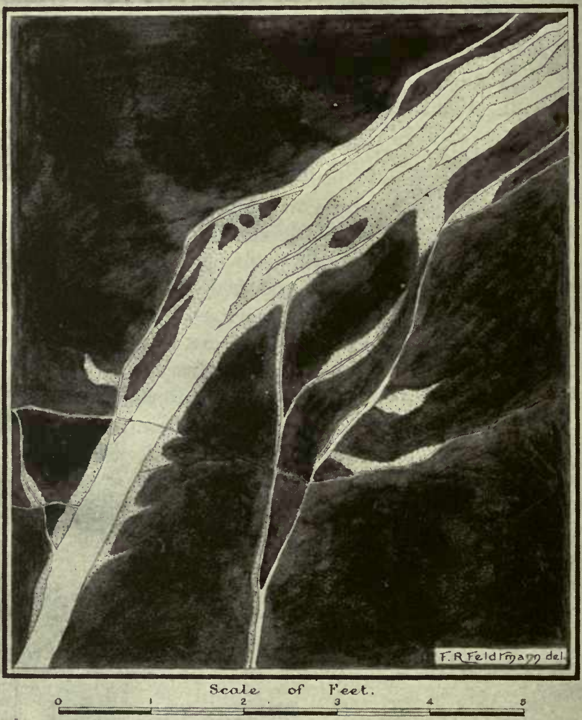
The chemical composition of specimens of these rocks is shown in Table I., Nos. 5, 6 and 7. In the eastern belt of these greenstones there is sometimes a tendency towards the gabbroid structure ([**13740**] A.W.A. United), found in some of the amphibolites.

Economically this group is the most important of any. On The Mile it, together with the bleached varieties, forms the country rock of most of the rich lodes. At the North end, lode formations are not so common in these rocks, the Golden Zone line of lode being the most persistent. Of considerable importance, however, are two series of quartz veins striking across the country, the one at about 30 degrees north of east and varying in dip from 60 degrees to the north to verticality; the other striking nearly east and west and dipping to the north at about 30 degrees. Both series carry good values, there being little to choose between them in this respect. Such veins have been worked to a very great extent in the Hannan's Reward-Mt. Charlotte mine and also in the Cassidy Hill, Cassidy's North, Maritana and Cunard mines.

(c) *The Bleached Greenstones.*

Between the type rocks of this and the previous group there is every gradation, and the relationship between the two is obvious when the rocks are seen together *in situ*. Typically, these are whitish to pale grey or pinkish rocks, usually of medium grain and

Fig. 1.



G.M.L. 211^E 'Charlotte' Main Shaft, 290 Ft. Level, S. Drive. Sketch showing bleaching of Quartz-dolerite greenstone round Cross Quartz Veins.

somewhat granitic appearance, but characterised by the presence of pyrites, often in large quantities. Although attaining a large development on The Mile, at the North End they are usually found as narrow bands a few inches in width on the walls of the cross quartz veins (*vide* Figs. 1 and 11). They differ from the rocks of the preceding group in the complete or almost complete absence of chlorite with the development of pyrite, which is sometimes found replacing leucoxene and greater quantities of quartz, sericite, and carbonates, and have evidently resulted from the action of sulphur-bearing solutions, and represent a greater degree of vein alteration than the preceding rock. Typical specimens are found on the Hannans Reward-Mt. Charlotte leases [2765, 2775], and also occur in a crosscut from the northernmost shaft in the A.W.A. United G.M.L. 4051E [12924]. Schistose varieties of these rocks are found in the east crosscut at the 290ft. level from the "Charlotte" Main Shaft [13464].

(d) *The Actinolite-Zoisite Amphibolites.*

The original forms of the rocks of this group would be extremely doubtful, were one to judge by the individual specimens alone. In general appearance, composition and usual absence of igneous structure, they closely resemble the second type of fine-grained amphibolites, with which one would be tempted to group the majority, were it not for the opposing field evidence. They can be separated into two subdivisions:—

(a) Those derived from quartz-dolerites, and

(b) Those derived from dolerites.

(a) The relationship of the rocks of the first subdivision can be more easily traced than those of the second. The only occurrence observed was a small outcrop in Hinemoa Street, between the previously mentioned areas of quartz-dolerite amphibolite and quartz-dolerite greenstone in that locality; the gradual passage of the actinolite-zoisite rock into the quartz-dolerite amphibolite could easily be traced in the field.

These rocks are fairly coarse in grain and of a somewhat mottled appearance. In the hand specimen, the long blades of greenish-grey hornblende can readily be traced by their lustre. In some sections these rocks are very similar to the normal quartz-dolerite amphibolites, except for the development of actinolitic hornblende, and remnants of an ophitic structure can be seen. Other sections sometimes from the same specimens as the last, present a more altered appearance, the felspars being represented by a mass of epidote and zoisite grains, whilst the structure is indefinite.

(b) The rocks of the second subdivision more closely resemble the fine-grained amphibolites in outward appearance. They are fairly hard, tough, dark greenish-grey rocks, fairly fine in grain, but the needles of actinolitic hornblende, though smaller than in the rocks of the first subdivision, are easily discernible. The outcrops of these rocks sometimes show spheroidal weathering. They are found in a roughly oval-shaped area extending southwards from the southern end of the Bonnie Play G.M.L. 4088E, through the western portion of the Fair Play G.M.L. 4052E and the north-eastern half of the Hidden Secret North G.M.L. 4035E. Some of the rocks now grouped as dolerite greenstones have evidently been derived from rocks of this type, as intermediate forms composed of actinolitic needles, party chloritised, in a ground-mass of carbonates and sericite, are found on G.M.L. 4035E and at the 400ft. level from the Hidden Secret main shaft.

The fact that the gradual passage of these rocks into the platy hornblendites (Bonnie Play G.M.L. 4088E, crosscut from a shaft 170 feet north-west of the east corner) and into the talc-chlorite-carbonate rocks derived therefrom (east crosscut from shaft on former G.M.L. 4080E, north-east of G.M.L. 4035E) can be traced in the field is strong evidence in favour of their inclusion in the Younger Greenstone series. An analysis of one of these rocks (Table II., No. 7), however, agrees very closely with those of the Older Greenstones. These are probably the rocks described by Thomson* as a thin band of fine-grained amphibolite separating the large "intrusion" of ultrabasic rocks from the main quartz dolerite dyke. Small and apparently unpayable lode-formations occur in these varieties of amphibolites, which, from an economic standpoint, may be disregarded.

(e) *The Dolerite Greenstones.*

Other than subdivision (b) of the actinolite-zoisite amphibolites, no dolerite-amphibolites were found within this portion of the field. Dr. Thomson, however, mentions† their occurrence as a local facies of the quartz-dolerite amphibolite at Kalgoorlie, the locality not being given; and he further states that they "are more abundant in the ridges to the west of the town."

On the other hand, dolerite greenstones, which are not mentioned by the last-named writer, occupy a fairly large area. The main belt of these rocks starts near the southern end of Williamstown and includes most of the area covered by the township, the western portion of the Hidden Secret group of leases, the Hannans Reward North, the Red White and Blue, part of the Sons of Gwalia, practically the whole of the Devon Consols, and probably the eastern portion of the Union Club G.M.L., ending probably in the vicinity of the boss of albite-porphyrite east of the Ivy. The belt of this rock in which the Mullingar quarry is situated has already been mentioned —its northern and southern extensions are obscured. Another small area is found east of the junction of the Bulong and Parkestown Roads, being exposed in a small quarry near the centre of the Bonnie Play lease; at its southern extremity this branch joins the area of actinolite-zoisite amphibolite. Another branch, probably joining the last in the Rising Sun G.M.L. 4039E, is found on the Fair Play, where it can be seen both in the mine workings and in a fairly prominent outcrop 200 feet south-west of the main shaft. Small patches of these rocks, not mapped, occur within the area shown as talc-chlorite-carbonate rock, with which they are so closely associated—there being apparent intermediate forms—as to suggest that they are variations of the same rock-mass.

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*Loc. cit., p. 623. †Loc. cit., p. 642.

Gibson makes no mention of these rocks under this title, but a portion of the area occupied by them was mapped by him as a "basic" variety of the "coarse-grained amphibolites";* the rock in the small quarry in the Bonnie Play he classes as a derivative of peridotite, but states† that it is rather on account of its agreeing very closely in analysis (Table II., No. 8) with the carbonated peridotite occurring on the western edge of Hannan's Lake than on its petrological characters. In section this quarry rock [**11029** and **12738**], as examined by Mr. Farquharson, is found to consist of fibrous platy chlorite, a fair amount of carbonate in shapeless plates, and also of irregular platy felspars largely kaolinised; a little quartz is present and also some rutile needles—these features hardly agree with those of an altered peridotite, and the analysis of so highly altered a rock can hardly be a guide, as there is frequently a migration of a portion of the original rock constituents; in the case of these rocks, as with the quartz-dolerite greenstones, the formation of the numerous cross veins of quartz would lower the silica percentage, whilst the introduction of CO_2 in large quantities would reduce the percentage of the other constituents; moreover, the relative proportion of MgO to CaO is less than that shown in the analysis of a platy hornblendite (Table II., No. 10); it must be admitted, however, that the percentage of alumina is somewhat low.

In general these rocks are composed of carbonates in large quantities, chlorite, felspars now chloritised or kaolinised; leucoxene and pyrite are frequently present, and in some specimens the presence of a little interstitial quartz links these rocks with the quartz-dolerite greenstones; micropegmatite is absent. Traces of an ophitic structure are occasionally found.

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* *Loc. cit.*, Plate I.

† *Loc. cit.*, p. 46.

Other than some of the fuchsite-carbonate-quartz rocks described later, the writer did not notice any bleached varieties of these rocks, although such may occur.

Economically the dolerite greenstones are of considerable importance, forming as they do the country rock of the Hidden Secret and Fair Play lodes, while numerous cross quartz veins have been worked on the Bonnie Play and Red White and Blue leases.

(f) *The Lustre-mottled Amphibolites.*

Rocks of this type are not found strictly within the limits of the map, but an outcrop occurs about 13 chains south of west from the Rifle Range hill, probably only a local variation from the quartz-dolerite amphibolite.

In the hand specimen these are massive, coarse-grained, dark greenish rocks, with large irregular hornblende crystals showing the characteristic lustre-mottling. A specimen from the above-mentioned outcrop proved in section to consist of nearly colourless to bluish-green hornblende, felspar largely epidotised and zoisitised, and irregular pieces of leucoxene; an ophitic structure was apparent. No analysis was made of this specimen, but for comparison with other types, that of a specimen [**2117**], somewhat carbonated, from the Great Boulder No. 2 main shaft, has been inserted (Table II., No. 9). A detailed description of these rocks is given in Dr. Thomson's paper.*

The lustre-mottled amphibolites are of no economic importance.

(g) *The Platy Hornblendites.*

Fairly fresh rocks of this type occupy an area which includes the south-western portion of the North End Extended G.M.L. 4485E and the greater portions of G.M.Ls. 4368E Dar Kan, and 4507E North End Deeps. Another small area, roughly on the same strike, but separated by the Bonnie Play branch of dolerite greenstone, is found at the junction of the Bonnie Play, Fair Play, and Fair Play Extended leases.

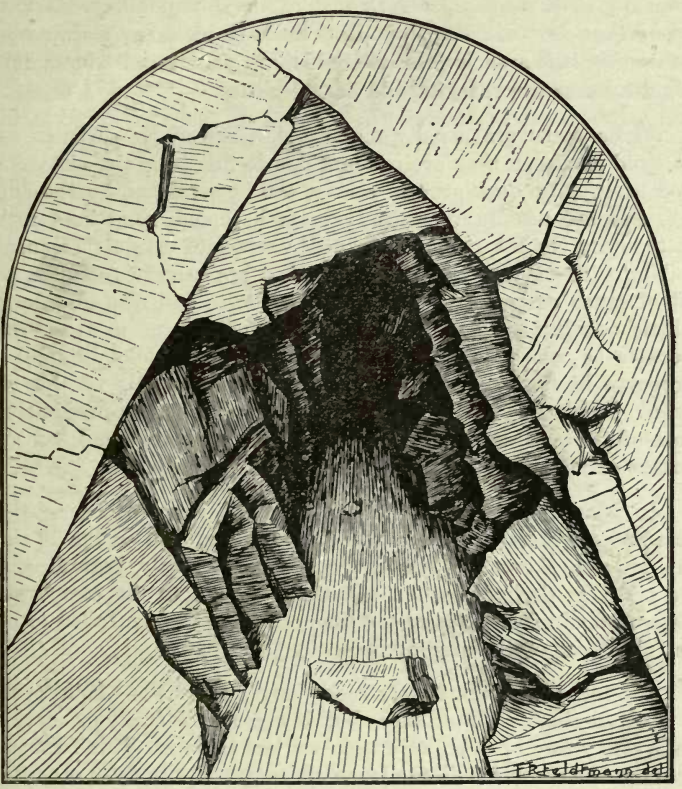
The hornblendites are tough, massive, dark greenish rocks, of medium coarse grain, wholly, or almost wholly, composed of aggregates of platy hornblende crystals of uniform grain [**12739**]; a marked sharply angular jointing is characteristic of these rocks (Fig. 2). In section the hornblende appears as large platy pale greenish crystals and also as extremely fibrous forms in a base of chlorite, carbonates, sphene, and fibrous hornblende. For an analysis of a specimen from a shaft near the western end of the boundary between the North End Extended and the Dar Kan leases, *vide* Table II., No. 10.

**Loc. cit.*, p. 639, *et seq.*

On Mr. Gibson's map* these rocks are included in the "basic amphibolites."

By the development of talc, chlorite, and carbonates the hornblendites pass through intermediate forms into the next group. They are of no economic importance.

Fig. 2.


F.R. Feldtmann del.

BONNIE PLAY G M L. 4088^E Eastern Shaft
Sketch showing sharply angular jointing of hornblendite

(h) *The Talc-Chlorite-Carbonate Rocks.*

These rocks are found over a wide area, reaching their greatest development in the more northerly portion of the area mapped. North of the Kanowna Railway line they appear to occupy the eastern half of the Younger Greenstone dyke. No unweathered outcrops are found, the rock being exposed only on dumps and in mine workings, but these are sufficiently numerous to enable a fair estimate to be formed of the extent of these rocks; their boundaries are entirely obscured. The northerly continuation of the main belt of these rocks beyond the limits of the map can be traced by a dump about three chains west of the western corner of the former Rifle Range Reserve 8353. South of the Kanowna Railway a smaller band starts near the laterite-capped hill south of the Devon Consols, and runs south to the southern end of the Bonnie Play. Another area occurs between the Fair Play and Hidden Secret mines; in places this last area is less altered than usual and shows intermediate forms approaching the hornblendites.

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* *Loc. cit.*, Plate I.

These rocks are usually massive, but sometimes schistose. In the hand specimen they are medium fine to fine in grain, either pale greenish-grey or dark grey in colour, can be scratched by the finger nail, and are usually very soapy in feel, though sometimes rather gritty owing to the number of small carbonate crystals frequently visible to the naked eye. In section they are usually found to consist of much carbonate, aggregates of chlorite and also of talc and a little quartz; rutile is common. Carbonate veins in these rocks prove to be composed of a ferriferous variety of dolomite, and the carbonate in the rocks themselves is probably largely of this character. Analyses of these rocks (Table II., No. 11) approximate to those of the hornblendites, the chief differences being the lower percentage of silica and the marked increase of potash.

In Mr. Gibson's map of the North End, the area occupied by these rocks is shown as "Quartzose Amphibolite," but on the 30-chain map he also shows two peridotite dykes, evidently regarding the talc rocks as derivatives of the latter. Owing to the comparative absence of mine workings at the time of his survey, he failed to note the full extent of the area occupied by these rocks.

The talc-chlorite-carbonate rocks have not, on the whole, proved of great economic importance, but low grade formations, such as the Mystery line of lode, have been worked therein. This formation occurs at the contact with the large albite-porphyrite dyke occupying the centre of the 10-chain map. 'Smith's lode,"* also in the talc-rocks is, so far as can be judged from the oxidised rock, a line of fuchsite-carbonate-quartz rock in which there are numerous cross quartz veins, in which the gold usually occurs. Other low grade formations such as those of the former Sir John and the Union Club leases appear to be associated with albite-porphyrite dykes, but in these instances the rocks are too decomposed for definite determination.

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* **Bulletin 51, pp. 41-42.**

(i) *The Talc-Mesitite Rocks.*

Only one small area of these rocks occurs within the limits of the map, namely, to the east of G.M.Ls. 4529E, 211E, and 97E, and in the South-Western portion of G.M.L. 796E. Its boundaries were nowhere visible, and those shown on the map do not pretend to any degree of accuracy. This area lies to the east of a belt of fuchsite-carbonate-quartz rock, with which it is evidently closely associated.

In the hand specimen these rocks resemble those of the preceding group, except for the marked development of very coarse mesitite ($2MgCO_3$ $FeCO_3$) crystals, sometimes reaching one-third of an inch in length [**13424-5**]. In addition to the coarse mesitite crystals they are largely composed of granular carbonates, some chlorite, large areas of talc, some quartz and occasionally felspar. The derivation of these rocks from an original peridotite is by no means certain. In chemical composition (Table II., No. 12) they differ from the preceding group chiefly in the very much higher ratio of the magnesia and ferrous oxide to the lime, while the alumina percentage is much lower. These rocks, together with the serpentines, represent the ultrabasic pole of the Younger Greenstone of the North End. No ore bodies have been found in the small area occupied by these rocks.

(j) *The Serpentines.*

Rocks of this character within this area are represented only by a specimen [**3391**] collected by Mr. E. S. Simpson from the dump of the old Kapai main shaft (now in G.M.L. 4320E, Ivy), and some fragments of a bore core from the 300ft. level of the same shaft. This bore was put in west from the west crosscut at this level for a total distance of 459 feet; the specimen examined is from a point 300 feet west of the crosscut. The lower levels of this shaft, from which several other interesting specimens have been obtained, were unfortunately inaccessible during my examination of the more northerly portion of the area, and although at a more recent visit I was able to get down to the 300ft. level, such portions thereof as were accessible were too much hidden by mud for much to be visible; moreover, the workings at this level appeared to be only in the jasper and the highly sheared and altered rock in the immediate vicinity. None of the serpentine rocks being found in the field, no defined area can be assigned to them on the map.

In the hand specimen these are fine-grained, soft, soapy greenish-grey rocks of fairly typical serpentinous appearance; a few carbonate crystals are visible to the naked eye. They are composed largely of aggregates of talc, with some serpentine, granular carbonates, and numerous magnetite grains. As compared with the previous group, the silica percentage (Table II., No. 13) is higher, that of CO_2 lower, showing that carbonation has taken place to a lesser degree; the alumina is slightly higher and the ratio of magnesia and ferrous iron oxide to lime is half as great again.

Serpentines are of frequent occurrence in the eastern goldfields and are usually found closely associated with dolerites or gabbros or their derivatives. They have not so far proved of any great economic importance so far as gold-mining is concerned.

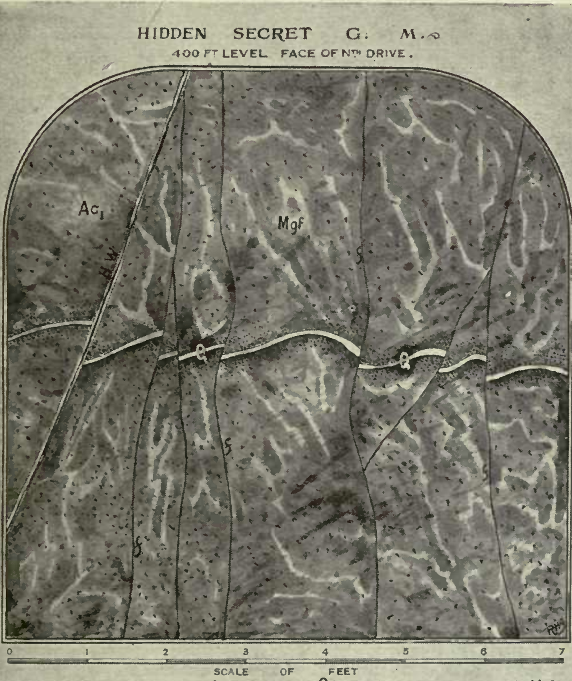
(k) *The Fuchsite-Carbonate-Quartz Rocks.*

Comparatively narrow bands of these rocks are of fairly common occurrence at the North End. They attain a width of 100 feet in places. The most persistent line runs northwards from the Hidden Secret—where it runs to the east of the main lode at the surface, but junctions with it at the 400ft. level (*vide* Fig. 15)—west of the Bonnie Play, through the Sons of Gwalia G.M.L. 3771E and the Devon Consols as far north as the Transcontinental Railway line; north of this it has not been traced. At its northern end this band is less well defined, and, owing to the absence of accessible deep workings in the two last-named mines, its exact boundaries were not determinable. A second band occurs on G.M.Ls. 211E and 97E to the west of the talc-mesitite rock; it can be best seen in the east crosscut at the 290ft. level of the "Charlotte" shaft on the former lease (*vide* Plate III.), where it is associated with bands of graphitic schist and an albite-porphyrite dyke. So far as can be judged from the oxidised rock, "Smith's lode," west of the Mystery lode, is another belt of this rock, while specimens [12257] were also obtained from the dump of a deep shaft near the centre of the Hyman G.M.L. 4406E. This last appears to be associated with the Mystery lode and is close to the northern portion of the large dyke of albite-porphyrite previously mentioned as occupying the centre of the map. Other smaller areas occur frequently associated with the lode-formations and usually in the vicinity of dykes of albite-porphyrite.

Numerous cross veins of milky quartz, usually auriferous, and resembling those of the greenstones are characteristic of these rocks (Fig. 3), the fuchsite scales being thickly congregated round the veins round which are also coarse and fine crystals of pyrite in fair quantities. Typical specimens are hard, medium fine to fine-grained, granular rocks, usually massive but frequently sheared and schistose and of a pale emerald green colour due to the fuchsite; veinlets of carbonate or cryptocrystalline quartz are numerous in them.

Analyses (Table I., No. 1, and Table II., No. 14) of two specimens agree fairly closely, both with each other and with that of the talc-mesitite rock, except that in the one from the Hyman the percentage of lime is very low, most of it having probably been removed from the body of the rock to be deposited in veins which were not included in the piece analysed; veinlets of carbonates in specimens from the Hyman and Hidden Secret show considerable effervescence with HCl, thus confirming this view. The CO_2 in the fuchsite rocks is nearly double that of the talc-mesitite rock, and the percentage of the other constituents is consequently lower; the combined water is lower, and much potash has evidently been introduced; the chromium percentage is almost identical. In the specimen from G.M.L. 211E the ratio of lime to magnesia and ferrous oxide is midway between that of the talc-chlorite-carbonate and talc-mesitite rocks. In general the analysis of [10913] agrees very closely with that of a similar rock from the Ingliston Extended G.M. at Meekatharra.* It should be mentioned that of the two North End specimens, that from the Hyman was associated with talc-

Fig. 3.



Sketch showing Southerly dipping cross quartz vein Q in fuchsite-carbonate-quartz rock Mgf, faulted by series of fault planes §. Hanging wall shear plane HW. & dolerite greenstone Ac₁.

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* G.S.W.A., Bulletin No. 43, p. 80.

chlorite-carbonate rocks, that from the Charlotte mine with talc-mesitite rock.

These rocks have been regarded by previous writers as highly altered peridotites, from their composition in general, and particularly the amount of chromium present; this is most probably the case in some instances, but close examination of the North End rocks in the field shows that they pass insensibly into the surrounding country, which may be dolerite-greenstone, talc-chlorite-carbonate, or talc-mesitite rocks; the inference being that they are the results of vein alteration of various rocks, certainly strongly basic in composition, and usually ultrabasic, but are not necessarily the highly altered forms of any one rock. That a high percentage of chromium does not necessarily prove the peridotitic origin of a rock is shown by the analysis of a hornblendite.

The close association of these fuchsitic rocks with dykes of albite-porphyrite is most noticeable and suggests that the solutions which attacked the original rocks were in some way connected with the intrusion of the albite-porphyrite.

It should be stated that except in the case of vein-altered specimens, no potash is present in those albite-porphyrites which have been analysed, but on the other hand the hornblende-porphyrites show a fairly high percentage, and if, as seems probable, these two rocks are closely connected, the potash may well have been introduced by later emanations from the porphyrite magma. The occasional presence of tourmaline in the fuchsite rocks tends to confirm this.

On the available evidence, then, it would seem most likely that these rocks in the North End, at any rate, are highly altered forms of the more highly basic members of the Younger Greenstones, and probably correspond to the bleached greenstones resulting from a similar alteration of the quartz-dolerites.

B.—INTERMEDIATE TO ACID INTRUSIVES.

(a) *The Hornblende-Quartz Porphyrites.*

A wide band of these rocks, largely obscured by superficial deposits, occupies the low-lying ground to the west of the town of Kalgoorlie, but only a small portion comes within the limits of the 10-chain map, of which it occupies the south-west corner. The only evidence of the occurrence of similar rocks in the main portion of the North End is that afforded by a somewhat sheared and carbonated specimen [2937] obtained by Mr. W. D. Campbell from a deep shaft 100 feet north of the west corner of G.M.L. 4458E, Hyman North, where it is evidently intrusive into the quartz-dolerite greenstone; this specimen was described in detail by Mr. Farquharson on p. 66 of Bulletin 51.

These rocks vary considerably in appearance and composition, but typical hand specimens show a dark greenish or brownish grey ground, with numerous white felspar phenocrysts and occasional small blebs of quartz; hornblende phenocrysts are fairly common in section, but are seldom visible in the hand specimen. (For analysis *vide* Table II., No. 15.)

Similar rocks are well developed at Bulong, where outcrops are common. In that locality, specimens from the one dyke show marked variation, some closely resembling the next group of rocks, pointing to a possible connection between the two. Unfortunately, specimens collected by the writer from that district have not yet been examined in detail.

Payable ore deposits have not yet been found in these rocks at Kalgoorlie—though such occur in similar rocks at Ora Banda—but it is probable that the gold-bearing solutions were closely connected with the parent magma, from which these rocks and the albite porphyrites were derived.

(b) *The Albite-Porphyrites.*

These rocks are of commoner occurrence at the North End than was previously suspected. Outcrops are infrequent and close examination is necessary to distinguish the weathered rock from highly decomposed forms of the Greenstones.

They are undoubted dyke rocks, and are usually found intruding the Younger Greenstones.

The largest dyke is that already mentioned as occupying the centre of the map, and described in Bulletin 51 as running through the Hyman, Mystery, and Lone Hand leases; it widens greatly to the south to a maximum of about nine chains near the Transcontinental Railway, where it is exposed at the western end of the cutting; before leaving the Milanese G.M.L. 4293E it appears to split, one branch running through G.M.L. 213E—the extent of this branch is not certain—the other through the Red White and Blue G.M.L. 1228E, Raven's lode occurring on the east side of the dyke, apparently a southerly continuation of the Mystery line of lode further north. Another large body of this rock, roughly oval in outline, is found to the east of the "Kapai" main shaft on the Ivy lease; specimens of this rock containing green, angular inclusions were obtained by Mr. W. D. Campbell from the lower levels of the shaft. Apparently other dykes, too decomposed to be determined with certainty, occur on the former Sir John lease to the north. Another series runs between the Mt. Charlotte-Reward Mine and Williamstown, associated with a number of jaspers, turning into graphitic schists at depth; the largest dyke of this series is found forming the western half of a small hill at the southern end of Williamstown. The northern members of this series are closely connected with the fuchsite rock exposed in the eastern crosscuts from the "Charlotte" main shaft, where the albite-porphyrite, somewhat sheared and carbonated in places, is also visible. Other dykes, too small to be shown on the map, occur in the Fair Play Extended and Bonnie Play leases, and further mining will probably disclose others.

The albite-porphyrites are fine-grained, hard, gritty rocks of a very pale, almost whitish grey colour, the more weathered rocks showing a reddish or pinkish tinge; they show a characteristic blocky jointing in the mass, and not infrequently contain small, angular, green, chloritic and sometimes chromiferous inclusions. Both phenocrystal and non-phenocrystal varieties of these rocks occur, the former being more common; both phenocrysts and groundmass are chiefly albite felspar; a little quartz is sometimes present in the groundmass. A specimen from the Mystery shows fairly numerous hornblende phenocrysts, visible to the naked eye, and resembles some of the Bulong hornblende-porphyrites. Rutile is frequently present and tourmaline is not uncommon, particularly between the planes of sheared varieties. Sericitised and carbonated forms are common.

An analysis of a fairly fresh albite-porphyrite (Table II., No. 16) agrees fairly closely with that of the hornblende-porphyrite, the chief difference being in the large amount of potash and lime present in the latter. In more altered forms of the former rocks, a fair amount of potash is present, evidently as sericite, and the percentage of soda is less.

So far as can be judged from the somewhat weathered examples in this area, ore bodies are sometimes found in these rocks, but more commonly occur at their junction with the Greenstones.

3.—THE SEDIMENTS.

But few exposures of probable sedimentary rocks are found within this area, and these occur only at the extreme north-east cornor of the 10-chain map. They are best shown at the old "Phœnix" brick pits, north of the Transcontinental Railway line, where a width of about 80 feet of these rocks—across their strike—in addition to their junction apparently with the fine-grained amphibolites, is exposed; unfortunately, the latter rock is too weathered to permit of definite determination.

These apparent sedimentary rocks occur as fine-grained, greyish and reddish, fairly soft, sandy beds, striking about 24 degrees west of north; the usual dip is to the west at about 75 deg., but near their junction with the amphibolites, they are contorted and faulted (Plate II., and Fig. 4.) These beds closely resemble the laminated slaty jaspers, as they appear in the oxidised zone,

Fig. 4.

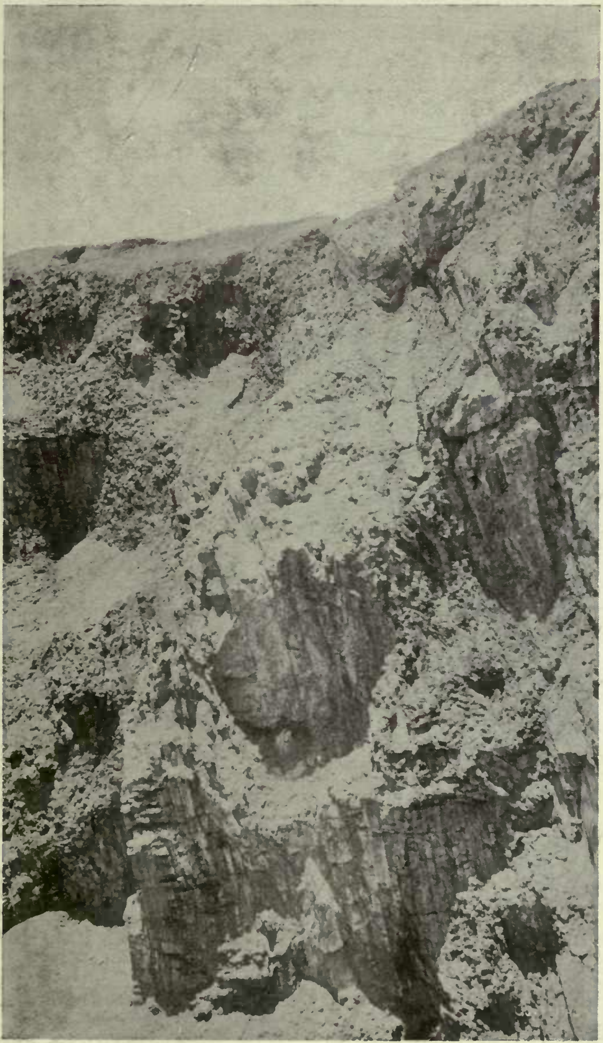

Photo: F. R. Feldtmann. Neg. F202.

Southern end of Phœnix Brick Pit, showing bedding of sedimentary rocks.

but are softer on the whole, although soft kaolinic and sericitic varieties of the jaspers occur in the North Collier and its immediate vicinity. It should be mentioned that the jaspers sometimes attain a width of 50 feet. Similar beds to those of the Phœnix brick pits are found in Walsh's quarry, in the flat west of Kalgoorlie, and beyond the limits of the map; these were regarded by Mr. Gibson* as sheared and weathered forms of the porphyrite. I do not consider that there is sufficient evidence for this assumption with regard to the Walsh's quarry rocks, although I am inclined to agree with Mr. Gibson regarding the rocks of White Cliff Quarry, about three miles south of Boulder; the rocks of the latter quarry are, however, somewhat different in appearance and do not show the bedding of the Phœnix brick pits and Walsh's quarry rocks. On the whole, I am inclined to the view that the Phœnix brick pit rocks are of sedimentary origin, although the evidence in favour of this is by no means conclusive.

So far, the sedimentary rocks have not proved of any economic importance.

4.—THE SUPERFICIAL DEPOSITS.

(a) *The Laterites.*

Lateritic deposits have been described so frequently in other reports, that no general description need be given here. Those examples found within the area under discussion are of the highly ferruginous variety, being mainly composed of hydrated iron oxide with some bauxite. Beneath the lateritic cap is a bleached kaolinic rock with occasional veinlets and patches of ferruginous matter and resulting from the removal of most of the iron from the original rock. For convenience, the term "Infralaterite" is proposed for this bleached rock. This infralaterite is often regarded by prospectors as an alluvial deposit, which at first sight it somewhat resembles, the laterite being regarded by them as the result of thermal action; both, however, result from the decomposition of the parent rock *in situ*. In the vicinity of lode formations or auriferous quartz veins, the infralaterite is sometimes found to carry gold in payable quantities, the metal having been dissolved by surface waters out of the lodes or veins, to be later precipitated as these waters percolated through the decomposed country rock. Mt. Ferrum is a good illustration (Fig. 5) of this.

Within this area laterites are most commonly found on hills within the area occupied by the talc-chlorite-carbonate rocks, also at the junctions of two or more Greenstone rocks; they are fairly common on the fine-grained greenstones and amphibolites, but are not found on the quartz-dolerite greenstones, except at their junction with other rocks. Only one occurrence was noted in the quartz-dolerite amphibolite—on the former Hannan's Find G.M.L. 4470E.

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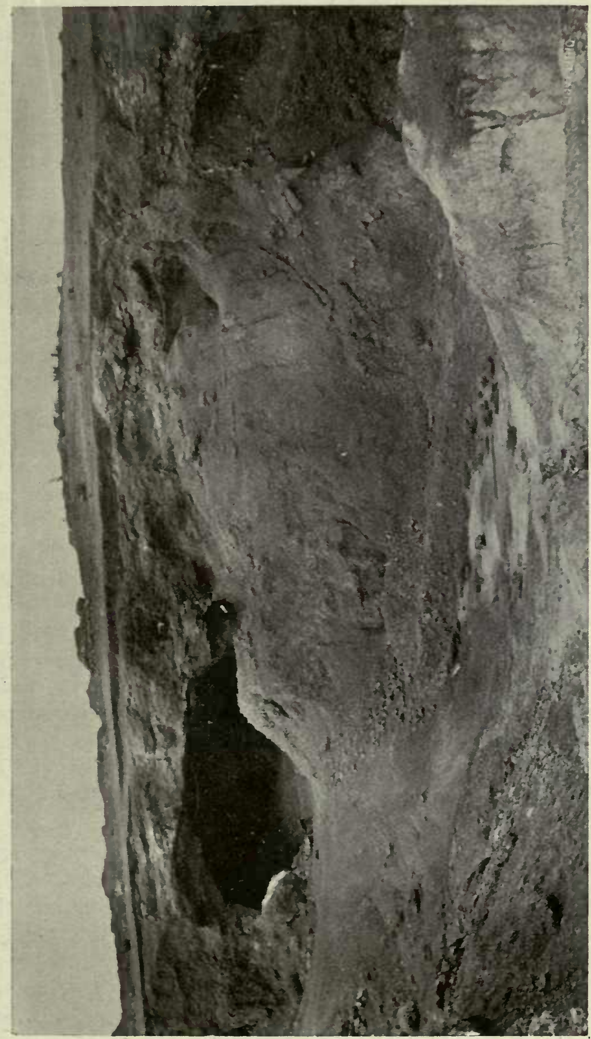
* *Loc. cit.*, pp. 40-41.

Fig. 5.



Mt. Ferrum from the North, showing workings under laterite.

Photo: F. R. Feldtmann. Neg. F200.

(b) *Sand, Loam, etc.*

In this group of superficial deposits may be briefly mentioned the gravel—including the ironstone gravel resulting from the weathering of the laterites—sand, loam, clay covering the lower lying ground and resulting from the action of wind, rain, and changes of temperature on the exposed rock surfaces. In addition, mention should be made of the "cement" or travertine so well known on these goldfields, and resulting from the action of surface waters which have dissolved the carbonates of the greenstone rocks to re-deposit them at the surface. It may be mentioned that in districts where amphibolites only occur, this cement is apparently not formed.

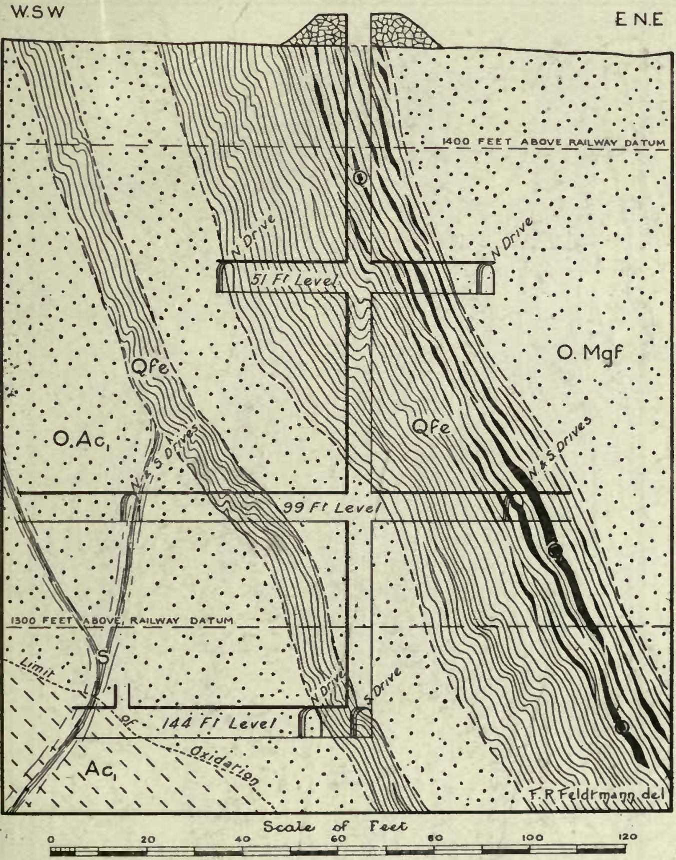
5.—JASPERS AND GRAPHITIC SCHISTS.

Jaspers and graphitic schists are of common occurrence at the North End, the former usually passing into the latter below the zone of oxidation. These rocks are usually of extreme length as compared with their width, the most persistent within this area having been traced from a point south of the junction of the Bulong and Parkestown roads, northwards through the Lucknow, Sons of Gwalia, Devon Consols, Union Club, Ivy and Sir John leases, thence across the Broadarrow road, near the north corner of the last-named lease; and in a general northwesterly direction beyond the limits of the 10-chain map, a total distance of nearly two miles. The irregular strike of this jasper is shown on the maps, and the sections show it to be equally irregular in dip; it attains its greatest width of, approximately, 50 feet along the western boundary of the Lucknow G.M.L. 4464E, where it can be seen in the mine workings (Fig. 6). In the oxidised zone, it is mainly composed of numerous thin fine-grained slaty laminæ of pale grey or brownish grey cryptocrystalline quartz [**12947**], in which a number of small tourmaline needles were observed in section. In places these slaty laminae are highly contorted (Fig. 7), and much resemble folded sedimentary rocks. In the eastern half of the jasper, coarse lenses of usually brown and more ferruginous compact, flinty quartz, sometimes two feet in thickness, and separated from each other by slaty laminae, are common (Fig. 8). At the limit of the oxidised zone, the jasper becomes highly pyritic in places and gradually passes into a black, laminated, highly graphitic rock, with veins and nodules, either circular or elliptical in outline, of pyrite, and consisting chiefly of quartz, sericite and innumerable fine particles of carbon. Much of the gold from the Devon Consols Mine was obtained close to the western wall of this jasper, rich patches occurring at its junction with coarse, flat cross quartz veins.

Other very similar but much shorter bands of jasper occur, for example, one running south from the Hannans Reward North lease to the Lady Elizabeth, where it is exposed in workings from the old main shaft; it forms a prominent little hill between the two leases (Fig. 9—photo).

Another series of short, thick lenses, striking nearly N.E.-S.W., outcrops on the Hidden Secret North and is exposed in a long crosscut at the 71ft. level on that lease. Of these two series, the first certainly, the second most probably, becomes graphitic at depth. Another short lens of jasper, composed of finely laminated grey siliceous bands occurs on the Milanese G.M.L. 4293E; since being mapped by the writer its outcrop has been covered by the slimes dump of that mine.

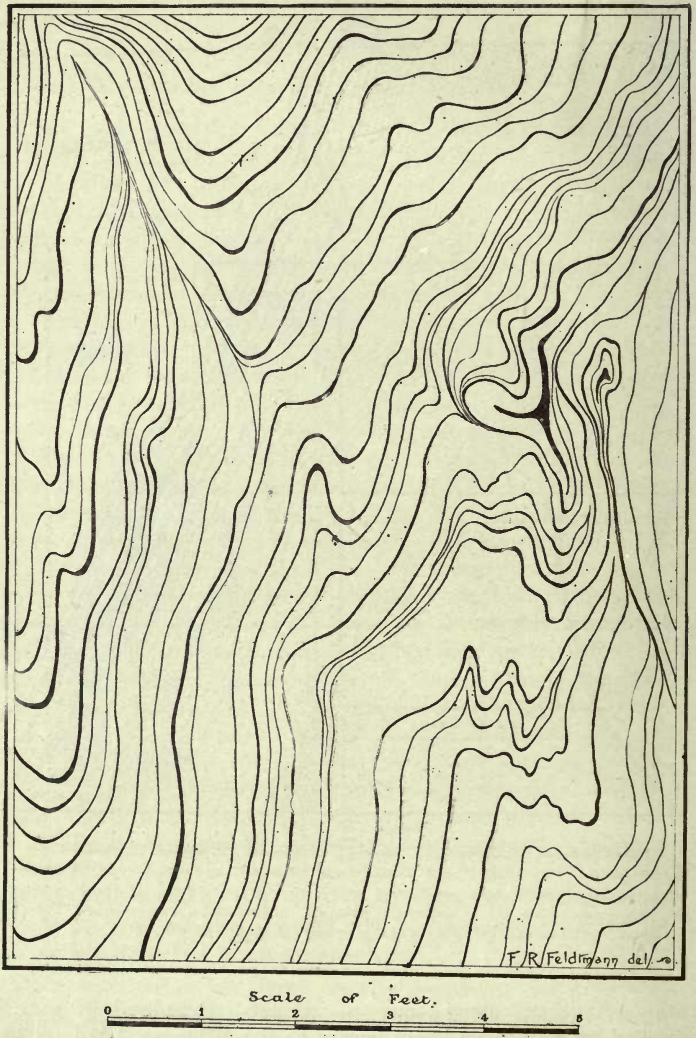
Fig. 6.



G.M.L. 4464^E LUCKNOW Shaft near W boundary Cross Section showing Jasper Qfe, with contorted slaty laminæ and lenses of flinty quartz Q; sheared zones S, in bleached dolerite greenstone Ac_1 (oxidised O.Ac_1), oxidised fuchsite-carbonate-quartz rock O.Mgf

Running through G.M.Ls. 1623E and 213E, on the eastern wall of the south-west branch of the main albite-porphyrite dyke, is another jasper; the workings on this were inaccessible.

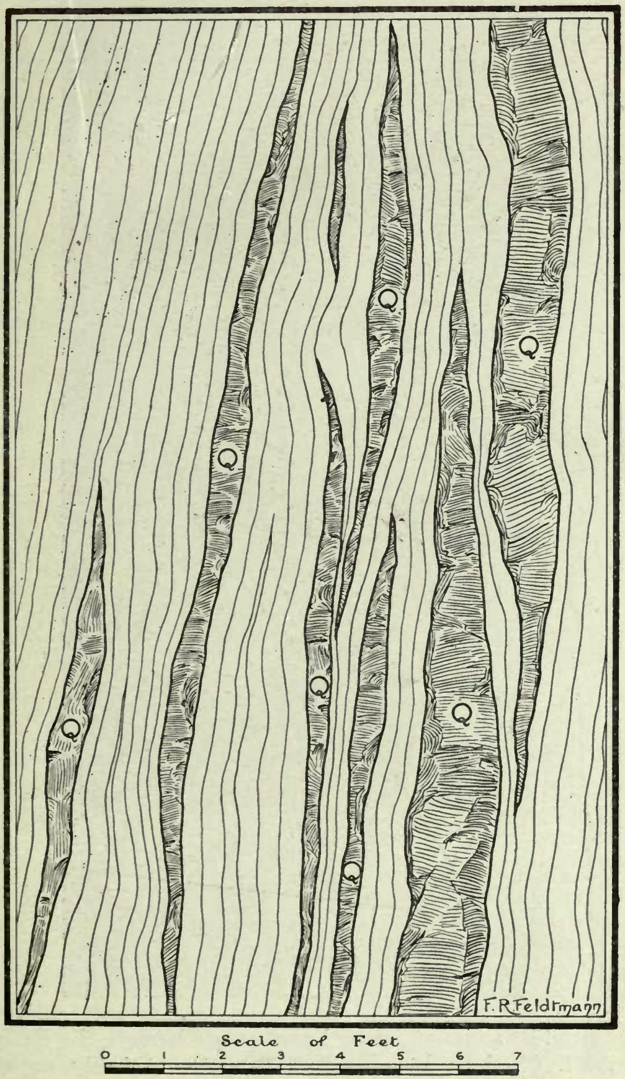
Fig. 7.



G.M.L. 3771^E - SONS OF GWALIA South Shaft, 99 Ft. Level, E. X cut Cross Section showing contorted laminæ of "Jasper"

A jasper very similar in appearance to that of the Milanese is found on G.M.Ls. 4485E, 4368E, and 4037E; it probably joins the

Fig. 8.



DEVON CONSOLS G.M — 149 Ft Level, South drive.
a Sketch Plan of 'Jasper' showing irregular lenses of brown flinty quartz Q, in grey, slaty, siliceous laminæ.

Westralia United main lode a little north of the main shaft, for coarse jasperoid lenses occur associated with the lode south of the shaft, and graphitic seams are found west of the lode at the bottom level of the mine.

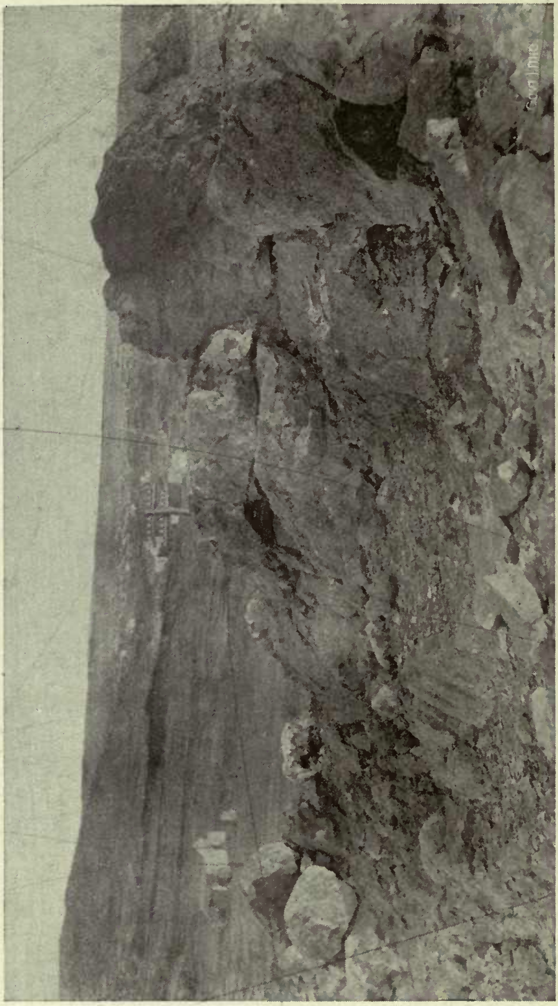


Fig. 9.

Photo: F. R. Feldtmann. Neg. F190.

Showing outcrop of jasper between the Hannan's Reward N. and Lady Elizabeth leases.

A persistent series of jasper lenses occurs between the Hannan's Reward-Mt. Charlotte leases and Williamstown, closely associated with the previously mentioned band of fuchsite-carbonate-quartz rock and series of albite-porphyrite dykes; what is apparently the northernmost lens of this series is exposed in the workings from a shaft on the western boundary of the Bonnie Lass G.M.L. 796E, but it is best seen in the east crosscuts from the "Charlotte" main shaft at the 190ft. and 290ft. levels (Plate III.). The section shown in the latter crosscut—from which a number of specimens were taken —is particularly interesting, and a description may be given here. As one goes west from the face of the crosscut, the fuchsite-carbonate-quartz rock [**13454**] becomes greyer in colour, and has apparently been highly sheared and brecciated, the rock being composed of small dark lenses of flinty appearance, but largely composed of carbonates with some quartz and chlorite, surrounded by greener, more schistose material composed of the same minerals but with more quartz and less carbonate; fuchsite is also present [**13455-6**]. At about 90 feet from the face a zone of grey carbonated pyritic rock with cross quartz veins dipping north at about 30 degrees is met with. West of this, the north drive 102 feet from the face of the crosscut is in a band of very pale grey schist composed of carbonates, sericite, and quartz [**13460**]. Within this is a narrow irregular band of greyish-black graphitic schist [**13459**] composed of quartz, sericite, with chlorite and rutile, and innumerable fine carbon particles. According to Mr. Farquharson, the form of the sericitic aggregates suggests former felspars and, with the quartz, give the rock a porphyritic appearance, suggesting that it may represent a highly sheared portion of the albite-porphyrite described later. West of the drive a very hard, pale grey, blocky and slightly schistose rock [**13461**] with some green angular inclusions is met with; this is undoubtedly a carbonated and sericitised form of the albite-porphyrite.

Between this and the small south drive is a completely crushed, grey, carbonated rock, probably derived from a greenstone.

Opposite the small drive is a thick lens of white quartz, with fairly fresh albite-porphyrite on its eastern side, and forming the west wall of the drive is a thin graphitic seam, apparently marking the junction between the albite-porphyrite and a pale grey coarse and highly schistose rock [**13464**] with numerous pyrite cubes and with irregular lenses of white quartz roughly parallel to the shear planes; this rock has already been mentioned under the bleached greenstones. West of this is a fairly fine-grained, pale grey schistose rock [**13465**] with numerous small greenish and a few larger and darker grey rounded inclusions. The origin of this rock, which is largely composed of carbonates, sericite, chlorite, and quartz, is doubtful; it may have been either the quartz-dolerite greenstone or the albite-porphyrite; a well-marked vertical plane, probably a fault line, and striking almost north and south, forms the western wall of this last rock, and on the western side of the wall there is an abrupt change to a dense, hard, dark-grey, fine-grained massive, but jointed rock [**13466**], undoubtedly the quartz-dolerite greenstone.

TABLE I.—*Analyses of Rocks from East Crosscut, 290ft. Level, and West Crosscut, 388ft. Level, Charlotte Shaft G.M.L. 211E.*

Analysis No.	1	2	3	4	5	9	7
G.S.M.	13454.	13459.	13461.	13464.	13466.	13472.	13473.
Rock	Fuchsite-quartz-carbonate rock.	Graphitic schist.	Carbonated albite-porphyrite.	Bleached greenstone.	Quartz-dolerite greenstone.	Quartz-dolerite greenstone with tourmaline.	Quartz-dolerite greenstone.
Locality	290ft. Level, Face E. Crosscut.	290ft. Level, S. Drive.	290ft. Level, E. Crosscut 117ft. W. of Face.	290ft. Level, E. Crosscut 144ft. W. of Face.	290ft. Level, E. Crosscut 166ft. W. of Face.	388ft. Level, N. Drive off W. Crosscut.	388ft. Level, Face of W. Crosscut.
SiO_2	36·08	74·89	60·62	38·27	43·63	39·41	42·15
Al_2O_3	4·47	14·56	10·96	14·09	12·77	11·97	11·26
Fe_2O_3	·19	1·62	·73	·33	·57	·56	·96
FeO	8·63	·51	2·04	5·54	11·08	9·02	9·51
MnO	·19	·09	·37	·24	·25	·22	·28
MgO	17·05	·71	5·57	4·10	5·11	6·03	6·28
CaO	4·65	·10	5·32	7·54	7·61	10·06	9·05
Na_2O	·29	1·86	1·86	1·35	3·02	·54	2·20
K_2O	1·26	1·04	1·56	3·38	·40	2·14	·22
H_2O + ...	1·02	2·11	2·05	1·33	2·75	1·21	2·40
H_2O —	·20	·30	·22	·13	·08	·07	·10
TiO_2	·26	·61	·38	1·31	·82	1·31	·82
CO_2	25·64	·12	8·32	11·58	11·58	15·46	13·81
C	..	·18	..	..	..	..	..
P_2O_5	·07	·07	·16	·11	·08	·04	·08
FeS_2	·10	·97	·32	10·49	·22	2·28	·44
Cr_2O_3	·45	..	·01	..	..	..	·01
V_2O_3	Trace	..	..	..	..	..	..
B_2O_3	·01	..	..	·65	..	·13	·05
F	..	..	..	·19	..	..	..
Total	100·56	99·74	100·49	100·63	99·97	100·45	99·62
				Less O = F ·08			
				100·55			
Sp. Gr.	2·94	2·69	2·75	..	2·83	2·89	2·86
Analyst	E. S. Simpson.	H. Bowley.	H. P. Webb.	E. S. Simpson and H. Bowley.	H. Bowley.	H. Bowley.	E. S. Simpson.

A variety of the jaspers somewhat different to the foregoing examples is found on the North Collier G.M.L. 4482E (*vide* Bull. 51, pp. 48-9, and Figs. 25 and 26), apparently in a small area of fine-grained greenstone surrounded by fine-grained amphibolite. On the surface this jasper resembles the commoner varieties, but at the 65ft. and lower levels it is represented by a very pale grey—almost white—clayey, finely laminated, somewhat fissile body, composed mainly of kaolin, sericite, and quartz, with some iron hydrate and possibly a little chlorite, while small crystals of tourmaline are extremely common. This rock, as seen underground, being so different to the hard siliceous outcrop, the owners of the lease imagined it to be a different formation. The surface rock had undoubtedly undergone further silicification by surface waters in a manner similar to the formation of laterite deposits. Associated with the jasper, on its western side, and with a slightly different strike to that of the main body, was a seam of dull greyish-black material described by the owners as an "indicator" vein, the best values occurring at its junction with the main body. This "indicator" was composed chiefly of kaolin coloured by finely divided graphite and containing numerous small crystals of tourmaline; associated with the vein, on fractures and between the cleavage planes, was much chloropal (Fe_2O_3, $3SiO_2$, $5H_2O$). It is probable that much of the gold in the shoot or "pipe" on this mine was deposited through the agency of vadose waters coming in contact with the "indicator."

A somewhat similar jasperoid formation, apparently without the silicified cap, occurs near the junction of the fine-grained amphibolites and the dolerite greenstones south of the Transcontinental Railway line.

Auriferous cross quartz veins are frequently associated with the jaspers; they seldom cut completely across the latter, but are usually found cutting into them a few feet, suggesting that these veins are younger than the jaspers. Similar occurrences were seen by the writer at Southern Cross, where also the occurrence of lode formations on the footwall of the jaspers appears to confirm this view. Moreover, Mr. E. de C. Clarke, in dealing with the relation of the quartz reefs and the jaspers at Sandstone and Hancock's,* after describing how the former cut across the latter, arrives at the same conclusion. It must be admitted, however, that some of the minor graphite seams found cutting across the carbonated rocks—for example, in the "Charlotte" shaft east crosscuts—have the appearance of being younger than the latter; nevertheless it is possible that the carbonation took place at a later date.

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* G.S.W.A., Bulletin No. 62, pp. 41, *et seq.*

Occurrence. From the foregoing descriptions, together with the maps, it can be seen that the graphitic schists, represented in the oxidised zone by the jaspers, are not confined to any one rock, but occur in this area:—

(a) In the Older Greenstones.

(b) At the junction of the Older and Younger Greenstones.

(c) In various members of the Younger Greenstone series.

(d) At the junction of the Younger Greenstones and the albite-porphyrites.

(e) In the albite-porphyrites.

In other words, the solutions from which the graphite was deposited travelled along the then available lines of weakness, whatever the rock. Moreover, the graphitic schists were formed at a period subsequent to the intrusion of the albite-porphyrites and, on the bulk of the somewhat meagre evidence available, prior to the formation of the ore deposits. Gibson, however, regards them as later.*

Origin. An organic origin was usually assigned by earlier writers to the graphitic schists—or "carbonaceous slates" as they have been termed. Later writers, however, such as Simpson, Gibson, Larcombe, Maclaren, and Thomson, are agreed on the igneous origin of the graphite. Cirkel,† after examining the various Canadian deposits, some of which are found in sedimentary rocks, others in igneous rocks, came to the conclusion that in some districts the graphite owed its origin to igneous magmas from which, in this case, granitic rocks had been formed, the mineral in one instance forming part of a pegmatite dyke to the same degree as the quartz or the felspar, and, further, he says:—‡

> "The graphite may have crystallised later than the felspar, but it has certainly crystallised before the quartz, and it was derived from the magma like these minerals."

Other graphitic deposits in igneous rocks, usually of an acid character, are found in New South Wales, Ceylon, etc., so that it is evident that the formation of graphite from the products of an igneous magma is by no means uncommon. Within this area the bands of graphitic schist occur in igneous rocks, and, moreover, in a variety of those rocks, at a very considerable distance from any possible sediments; and, in addition to the main bands of these rocks, the graphite sometimes occurs in narrower seams, evidently original joints or shear planes; it is evident, therefore, that the theory of a sedimentary origin is not tenable as regards the Kalgoorlie graphitic schists at any rate.

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* *Loc. cit.*, p. 28.

† "Graphite—properties, deposits, treatment and uses," pp. 87, *et seq.*

‡ *Loc. cit.*, p. 91.

But while it is easy to prove an igneous origin for the graphite, it is a very different question when we come to the manner of its deposition. That the graphite was emitted from the magma in the form of some compound of carbon is most probable, for it is unlikely that the exceedingly high temperature required for its existence in the liquid or gaseous form uncombined was ever attained. Simpson,* discussing the occurrence of methane in graphitic schist in the Great Boulder Proprietary mine, regards the latter as—

> "shear zones in the greenstone into which hydrocarbons of volcanic origin have penetrated, depositing finely divided carbon in them during slow combustion. This oxidation may have been at the expense of oxygen in the pores of the rock, or at the expense of ferric compounds capable of reduction to a lower state of oxidation.''

The formula for this would be

$$CH_4 + O_2 = C + 2H_2O.$$

Larcombe,† however, considers that

> ''the carbon is so closely associated with vein formation, which does not take place at high temperatures, whereas''—he states—''I can so far find no literature to show any reaction for the decomposition of hydrocarbons—with formation of graphite—below 500°C, the temperature expected under the conditions of vein-formation. It is therefore more likely that the methane is formed as an after effect, for the graphites were powerfully slickensided after their formation, though some hydrocarbons may have been left undecomposed.''

He further quotes Weigert's formula—

$$C + 2H_2O = CO_2 + 2H_2$$

reversed below 500°C, and concludes with the opinion—

> ''that the formation of carbon is due to the deoxidation of carbon oxides that existed in the vein solutions and along the sheared lines.''

Although the graphitic schists are closely associated with highly carbonated rocks, resulting from vein-alteration on a large scale—petrological examination and chemical analyses showed that no carbonates were present in specimens collected by the present writer. In typical specimens these rocks are composed chiefly of cryptocrystalline quartz, with disseminated graphite dust, while the not infrequent occurrence of tourmaline suggests that it was formed at the same time. Mr. Simpson mentioned verbally to the writer specimens in which carbonate crystals were seen, but occurring in such a manner as to suggest a later origin, and it is difficult to understand why solutions containing carbonic acid should at the same time in a few instances deposit graphite, in others form carbonates, apparently under similar conditions. It seems probable on the evidence of the barren shear zones described later, that the period of carbonation, in part at any rate, was later than that of the formation of the graphite—on the assumption that the latter preceded the period of ore deposition—although it is probable that carbonation extended over a long period of time, and it appears that in volcanic regions the emission of CO_2 belongs to the later periods of gaseous activity,* whereas that of CO and CH_4 belong to an earlier period. As we have seen, methane has certainly been found associated with the graphitic schists, but whether conditions were such as to permit of the decomposition of hydrocarbons† during the period of the formation of these rocks, there is little evidence to show.

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* "Natural gas in the Boulder Mines," G.S. W.A., Bull. No. 42, p. 160.

† "The Geology of Kalgoorlie," Mining and Scientific Press, Vol. III., No. 7, p. 240.

As regards the silica percentage—while analyses of Kalgoorlie specimens show percentages ranging from 60 to 84, those of two from the Sandstone district are, roughly, 54 and 57, while at Southern Cross the percentages range from 45 to 78, the latter being exceptional. On the average the silica percentage is not much higher than that of the average greenstones, while that of the rocks in the vicinity with the exception of a specimen of a carbonate-albite-porphyrite is lower than usual, so that it is probable that most of the silica has been derived from the country rock, although some may have been introduced by the magmatic solutions.

So far, then, as the evidence goes, it seems most likely that at some period subsequent to the intrusion of the albite-porphyrites and prior to the period of ore deposition—though probably without a break between it and the latter—the graphitic schists were formed by the invasion of highly sheared zones in the igneous rocks by highly active and probably somewhat siliceous solutions containing gaseous carbon compounds, possibly oxides, but more probably hydrocarbons such as methane, and that these solutions were derived either from the albite-porphyrite or from the parent magma which gave rise to the latter.

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* F. W. Clarke, "The Data of Geological Chemistry," U.S.G.S., Bull. No. 491, pp. 275-6.

† Mr. E. S. Simpson has suggested to the writer the deposition of the graphite from the action of acetylene (C_2H_2) on the ferric compounds with the formation of methane, free carbon and water.

TABLE II.—*Analyses of Rocks from the North End, Kalgoorlie.*

Analysis No.	1	2	3	4	5	6	7	8
G.S.M.	11033.	13451.	13773.	11008.	10436.	13473.	12731.	11029.
Rock	Fine-grained amphibolite.	Fine-grained greenstone.	Fine-grained greenstone.	Quartz-dolerite amphibolite.	Pegmatitic amphibolite.	Quartz-dolerite greenstone.	Actinolite-zoisite amphibolite.	Dolerite greenstone.
Locality	G.M.L. 4370E.	G.M.L. 4063E, Fair Play Extended.	G.M.L. 4230E, Mt. Ferrum Consols.	G.M.L. 211E, Mt. Charlotte.	G.M.L. 3770E, Eaglehawk United.	G.M.L. 211E, Mt. Charlotte.	G.M.L. 4385E, A1.	G.M.L. 4088E, Bonnie Play.
SiO_2	51·72	50·05	49·81	47·12	44·17	42·15	52·37	42·65
Al_2O_3	14·63	12·77	12·38	16·18	10·57	11·26	13·90	4·69
Fe_2O_3	2·02	1·12	·78	3·23	9·20	·96	2·37	·61
FeO	8·26	7·86	7·03	6·90	10·92	9·51	7·41	7·64
MnO	·48	·34	·24	·45	·51	·28	·24	·48
MgO	7·50	6·51	5·04	7·23	4·56	6·28	7·99	15·22
CaO	8·10	8·68	6·91	13·80	9·12	9·05	10·81	7·94
BaO	..	..	..	..	·01	..	..	..
Na_2O	2·42	1·34	1·10	1·54	1·94	2·20	1·52	·30
K_2O	1·38	·48	1·74	·11	·16	·22	·06	·06
H_2O + ...	2·94	4·42	2·82	1·92	2·28	2·40	2·68	1·32
H_2O —	·06	·13	·02	·09	·16	·10	·10	·09
TiO_2	·51	·33	·60	·72	4·99	·82	·77	·20
CO_2	·05	6·31	10·92	..	·35	13·81	·12	18·07
P_2O_5	·11	·14	·10	·15	·40	·08	·11	·19
FeS_2	·19	·02	·30	·22	·26	·44	·26	·30
Cr_2O_3	·02	·05	·03	..	..	·01	..	·40
V_2O_3	·06	·06	·03	·01	·19	..	..	..
B_2O_3	..	..	..	..	..	·05	..	..
Total	100·45	100·61	99·85	99·68	99·79	99·62	100·71	100·16
Sp. Gr.	2·94	2·79	2·85	3·10	3·27	2·86	3·00	2·84
Analyst	H. Bowley.	E. S. Simpson.	H. Bowley.	H. Bowley.	E. S. Simpson.	E. S. Simpson.	H. Bowley.	E. S. Simpson

TABLE II.—*Analyses of Rocks from the North End, Kalgoorlie*—continued.

Analysis No.	9	10	11*	12	13*	14	15	16
G.S.M.	2117.	11003.	12240.	13424.	3391.	10913.	2943.	12331A.
Rock	Lustre-mottled amphibolite.	Hornblendite. p 32	Talc-chlorite carbonate rock.	Talc-mesitite rock.	Serpentine.	Fuchsite-quartz-carbonate rock.	Hornblende-quartz porphyrite.	Albite-porphyrite.
Locality	G.M.L. 1219E, Gt. Boulder No. 2 South.	G.M.L. 4157E, Hannan's Hope Extd.	G.M.L. 4406E, Hyman.	G.M.L. 796E, Bonnie Lass.	G.M.L. 4320E, Ivy.	G.M.L. 440E, Hyman.	W.R. 3398.	G.M.L. 4406E. Hyman.
Si_2O	44·23	46·26	35·90	36·52	47·44	33·80	65·66	69·02
Al_2O_3	10·89	9·01	13·48	5·42	6·65	5·72	13·55	15·92
Fe_2O_3	·13	·67	7·04	·86	·76	·40	1·63	·58
FeO	14·22	10·41	4·12	9·88	6·78	8·70	1·56	1·90
MnO	1·60	·56	..	·22	..	·19	·23	09
MgO	11·42	19·65	15·69	23·17	26·68	19·95	1·56	2·63
CaO	10·43	6·94	5·81	4·84	3·39	1·34	5·46	·29
BaO	..	..	..	..	..	..	·03	..
Na_2O	1·02	·30	·26	·38	·33	·30	5·00	7·48
K_2O	·20	·10	2·00	·10	..	2·11	1·96	..
H_2O + ...	4·25	4·42	4·71	4·42	5·68	·59	·46	1·02
H_2O —	·22	·14	1·84	·18	·78	·09	·10	·28
TiO_2	·06	·54	..	·20	..	·33	·50	·57
CO_2	1·29	·20	9·22	13·78	2·06	25·98	1·58	·14
P_2O_5	..	·21	..	·14	..	·11	·54	·28
FeS_2	·26	·19	..	·17	..	·24	·02	·11
Cr_2O_3	..	·20	..	·42	..	·50	·01	..
V_2O_3	..	·10	..	·02	..	Trace	·01	..
B_2O_3	..	..	..	..	..	ZrO_2 = ·02	ZrO_2 = ·02	..
Total	100·22	99·90	100·07	100·72	100·55	100·37	99·88	100·31
Sp. Gr.	3·00	2·96	..	2·88	..	2·97	2·75	..
Analyst	C. G. Gibson.	H. Bowley.	..	H. Bowley.	..	E. S. Simpson.	H. Bowley.	..

* Partial Analysis only.

III.—THE ORE DEPOSITS.

The ore deposits of the North End may be classified as follows:—

1. Primary ...
    - A.—Lode formations ...
        - (*a*) Quartzose.
        - (*b*) Schistose.
    - B.—Cross quartz veins.
2. Secondary ...
    - A.—Impregnations in the zone of oxidation.
    - B.—Detrital deposits ...
        - (*a*) Eluvial.
        - (*b*) Alluvial.

1. A.—THE LODE FORMATIONS.

The subdivision of the lode formations within this area is no easy matter, particularly as investigations were, in many instances, confined to the oxidised zone. There is a mergence of the different types into each other, and any one deposit differs in minor particulars from the others. On the whole the most important factors seem to be the original composition of the country rock and the degree of alteration to which it has been subjected, the latter depending partly on the amount of shearing it has undergone, partly on the strength and quantity of the ore-bearing solutions.

The following appears to be the simplest and most natural subdivision:—

(a) Quartzose lode formations.

(b) Schistose lode formations.

(a) *The Quartzose Lode Formations.*

These appear to be confined to the quartz-dolerite greenstones or the bleached forms of those rocks. As mentioned by Gibson,* they differ from those of the schistose type in the greater amount of replacement of the original minerals by crypto-crystalline quartz in the lodes of the former type, whereas those of the latter type are largely carbonated and their schistose character is more apparent—this being largely obscured in the quartzose lodes by metasomatic replacement. The greater quantity of silica present in the lodes of this type is due, no doubt, not only to the more complete alteration of the country rock, but also to the greater quantity of silica present in the original rock—this type being, as already stated, confined to the less basic members of the Younger Greenstones.

Practically the only example of the quartzose lodes within this area is the Golden Zone line—one of the most persistent lode channels of the North End, described in Bull. 51, p. 17. As stated in that report—

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* *Loc. cit.*, p. 49.

''the main body of this lode consists chiefly of crypto-crystalline quartz and is the result of complete metasomatism of the country rock along a line of shearing. The lode passes insensibly into the country rock, the latter having been subjected to metasomatic action for some distance beyond the ore body.''

The country rock in the vicinity of the ore-body is composed chiefly of carbonates, quartz, sericite, chlorite, albite, and iron ores. It should be mentioned that this lode is not so typical an example of the quartzose lodes as some of those on the Western side of the Golden Mile.

(b) *The Schistose Lode Formations.*

These are found both in the Older and Younger Greenstones, also at the junctions of the rocks of the two series and at the junctions of the latter with the albite-porphyrites. As these formations in some of the rock types present features differing from those in other types, the lodes of the different rocks will be discussed seriatim.

Schistose Lodes in the fine-grained Amphibolites. Only one formation carrying values apparently in the fine-grained amphibolites was seen by the writer, namely, on the eastern boundary of former G.M.L. 449E, Colleen Bawn (Fig. 10). The country rock was, however, too decomposed for determination and may have been the corresponding greenstone, which certainly occurs about 10 chains to the west. The formation was particularly flat in dip, and probably joins the northern portion of the Westralia United lode channel at a depth of, roughly, something over 450 feet, beneath the Kanowna road. Values had evidently been obtained in this formation, since a little stoping had been done at the 110ft. level. As the work was not carried below the oxidised zone, no description can be attempted, but it probably bears the same relation to the lodes of the fine-grained greenstones as the schistose formations of the quartz-dolerite amphiboltes bear to those in the quartz-dolerite greenstones.

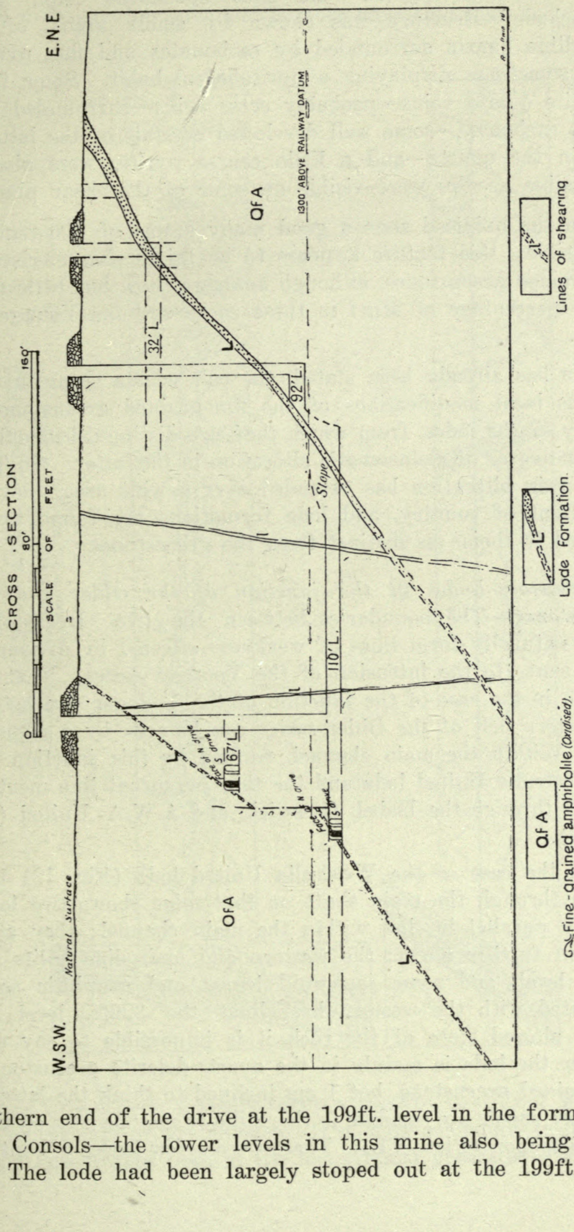
Schistose Lodes in the fine-grained Greenstones.—There are a fair number of schistose lodes in the fine-grained greenstones; most of these seem to join a main channel—previously mentioned in the description of these rocks—running close to the junction of the Older and Younger Greenstones.

Among the most typical formations in the fine-grained greenstones may be mentioned the Isabel and Brown Hill Junction lodes (Plates IV. and V.). In each case there are two main parallel ore channels. In the Brown Hill Junction they appear to join at a depth of about 240 feet in the cross section through the main shaft; another parallel line, apparently poorer in value, occurs about 50 feet east of the main line in this mine. The main levels of the

Isabel were unfortunately inaccessible, so that no description of the lode below the oxidised zone can be attempted. Along the Brown Hill Junction main line the sulphide zone was only encountered at

Fig. 10.

G.M.L 4490E COLLEEN BAWN.



Showing lode formation in fine-grained amphibolite.

the southern end of the drive at the 199ft. level in the former Mt. Ferrum Consols—the lower levels in this mine also being under water. The lode had been largely stoped out at the 199ft. level, but from the rock in the vicinity and specimens on the dump, it was probably composed of highly schistose matter consisting largely of carbonates—probably chiefly ferriferous dolomite—with some crypto-crystalline quartz, sericite, probably some albite, and a fair amount of pyrite. In some specimens from the dump a "cockade" structure was shown by small areas of crypto-crystalline quartz surrounded by carbonates and fine pyrites—the latter sometimes displaying a pyritohedral habit. Some fragments of white quartz veins—probably cross veins—surrounded by ferriferous carbonate—some well developed crystals of the latter occurring in the quartz—and a little coarse pyrite, were also found; tourmaline needles were visible on some of the shear planes.

In the oxidised zone a good many seams of manganese oxide are visible; this feature appears to be fairly characteristic of the fine-grained greenstones, although analyses show but little difference in the percentage of MnO in these rocks and the Younger Greenstones.

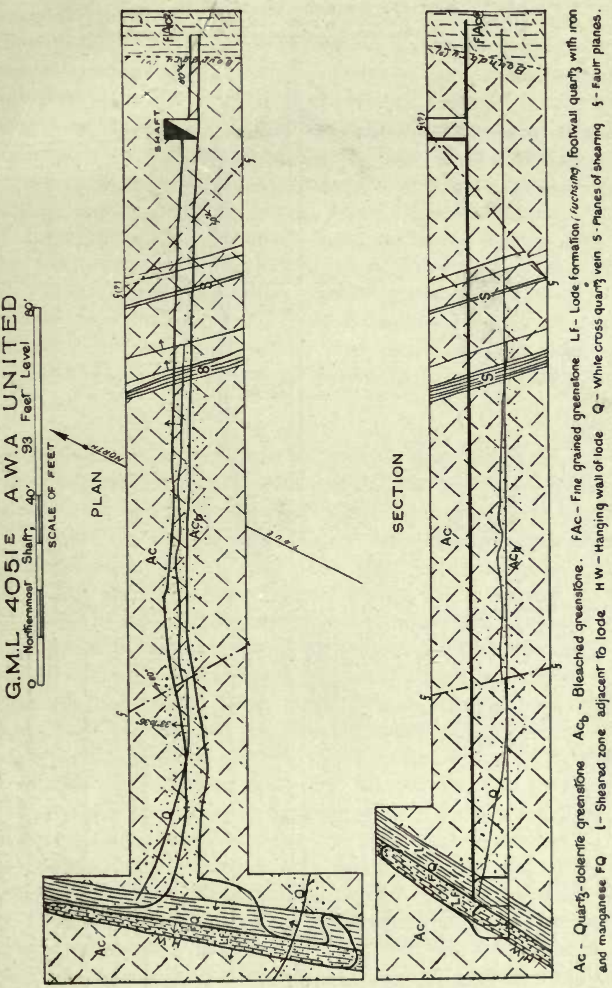
As has already been stated, the calc-schists occur in this area only as local modifications of the fine-grained greenstones in the vicinity of the lodes, from which they are distinguished only by the greater degree of metasomatic alteration in the latter. On The Mile, where vein alteration has extended over a wide area, they cover a big extent of country, and lode formations are found apparently confined to them—as distinct from the greenstones.

Schistose Lodes at the junction of the Older and Younger Greenstones.—The boundaries between the two Greenstone series would naturally form lines of weakness affected by dynamic action subsequent to the intrusion of the Younger series. That this has been so in the case of the junction of the Younger Greenstones and the eastern belt of the Older series can be seen by a glance at the map. Within the main channel, formed by this junction line, are the Westralia United lode and the thin persistent line mentioned as passing through the Isabel, Creswick, and A.W.A. United (Figs. 11 and 12).

In the case of the Westralia United lode (Fig. 12) the cross section through the main shaft on that mine shows two lode lines, roughly parallel in dip, within the main channel; they appear to junction further north; the western and main line splits near the 231ft. level, and some jasperoid lenses and graphitic seams are associated with the western branch at the 329ft. level. Owing to the altered state of the rock it is impossible to say definitely whether the lode is mainly in the quartz-dolerite greenstone or the fine-grained greenstone, but I am inclined to think the latter. Irregular ore shoots are common in this mine, as may be seen on the longitudinal section (Plate VI.). There were a few lenses of flinty quartz in these shoots, but in the main the lode consists of highly schistose, carbonated rock—probably more chloritic than is usual with the lodes—with some irregularly distributed fine pyrite.

The Isabel-A.W.A United line (*vide* maps and Fig. 11) is of quite a different character and is more quartzose than usual with the schistose formations; it really forms a class by itself, but is discussed here for the sake of convenience. It is more commonly in the quartz-dolerite greenstones than in the fine-grained greenstones at the sur-

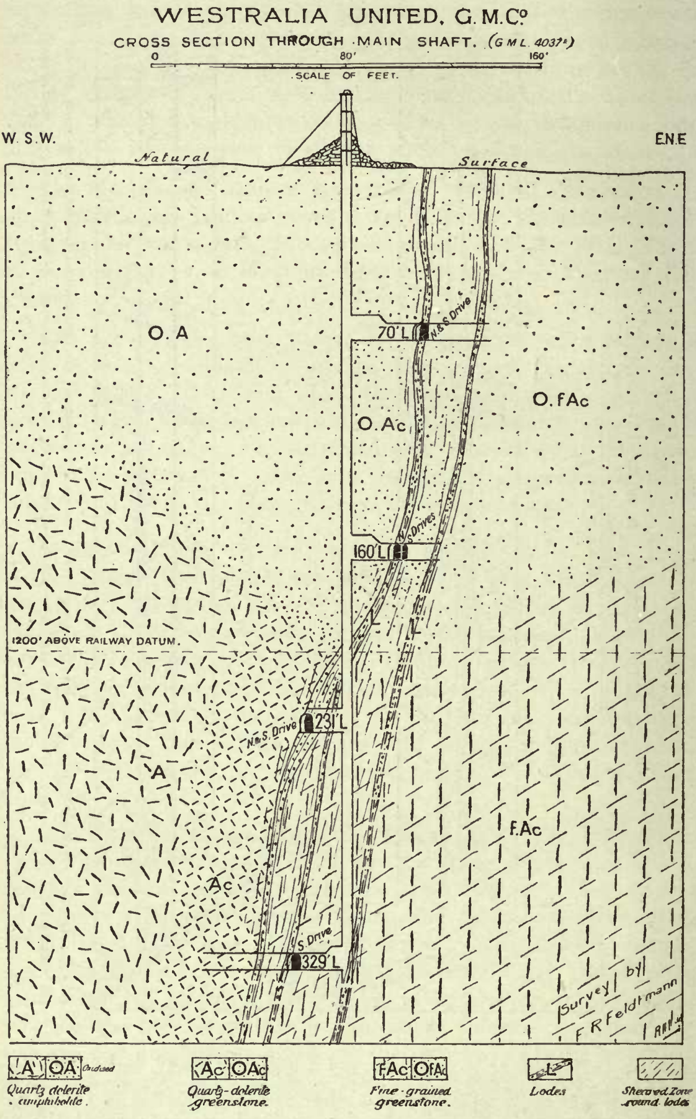
Fig. 11.


G.M.L 4051E A.W.A UNITED
Northernmost Shaft, 93 Feet Level
0 40' 80'
SCALE OF FEET
PLAN
NORTH
SECTION
SHAFT
Ac
Ac_b
fAc
LF
FQ
HW
Q
S
Ac - Quartz-dolerite greenstone Ac_b - Bleached greenstone. fAc - Fine grained greenstone LF - Lode formation (fuchsing). Footwall quartz with iron and manganese FQ l - Sheared zone adjacent to lode HW - Hanging wall of lode Q - White cross quartz vein S - Planes of shearing ʃ - Fault planes.

Sketch plan and section, 93ft. level, nothernmost shaft.

face, and appears to dip sharply to the west, away from the junction. In strike it is more nearly north and south than is usual with the lode formations. It is a narrow, usually well-defined body,

Fig. 12.



usually from two to four feet in width—but occasionally pinching to a thin seam—consisting of irregular veins of milky quartz with, in the oxidised zone, much ferruginous and manganiferous matter. One quartz vein was seen by the writer with a width of one foot, in one instance—in this case the quartz was seamed with numerous cross joints carrying manganese oxide. These quartz veins were vughy in places and a fair amount of fuchsite was visible round them. At one point near its southern end, in fine-grained greenstone—in a shaft on former G.M.L. 4450E—this formation presents a most peculiar appearance, consisting of purplish-grey matter, with a marked, apparent flow structure—probably due to brecciation—in which there were numerous creamy white augen. The darker material was found on examination to consist largely of strings of tourmaline grains, between which were small quartz plates in a minute mass of quartz and kaolinic matter, with, in places, some micaceous fibres. A good deal of ferruginous and probably manganiferous matter and some irregular white quartz on the hanging-wall were associated with this breccia. This formation seldom carries payable values except at its junction with the numerous lode formations which run into it from the fine-grained greenstones; such patches have been found in the Creswick and Isabel, and, no doubt, further prospecting would reveal others.

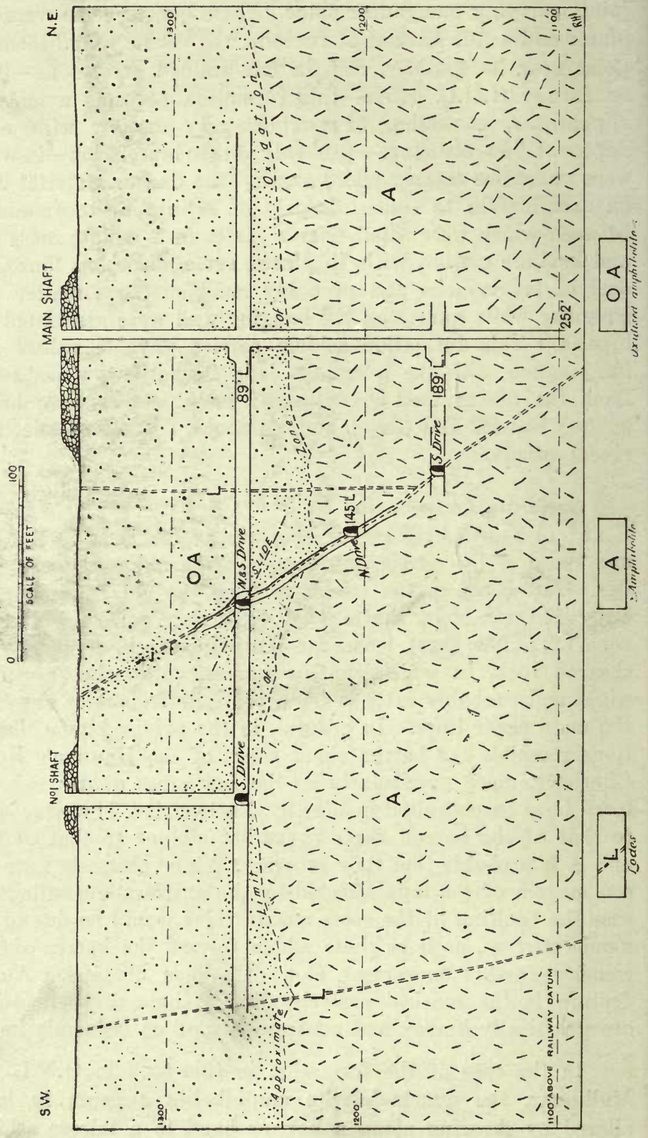
Schistose Lodes in the Quartz-Dolerite Amphibolites.—As mentioned in the description of those rocks, but few lode formations, and those of low grade, are found in the quartz-dolerite amphibolites. As shown in the workings from the old Bohemian Girl and Lady Forrest main shafts (Fig. 13) they consist in the oxidised zone of a few short lenses of flinty quartz in a narrow band of sheared rock, in which the metasomatic alteration appears to be slight and probably extends for a very short distance outwards from the main shear lines. In general, in the oxidised zone these formations resemble the barren shear zones of the Hannan's Reward-Mt. Charlotte, more particularly as the few cross quartz veins encountered have been faulted in places. Their strike, however, is different to that of the barren shear zones but similar to that of the lodes, and it is probable that they represent minor channels near the western margin of the area affected by the auriferous solutions. In this case the faulting of the cross quartz veins would be due to later dynamic stresses, such as those which formed the barren shear zones, causing further movement along the lode channel. An unusual feature is the marked easterly dip. Whatever their origin they are practically barren and consequently of no economic importance.

In the case of the formation in this rock in G.M.L. 4524E at Mullingar, the quartz-dolerite amphibolite appears to have been altered by shearing along a narrow band to a talcose schist. This formation also appears to be low in value; it seems to be rather more quartzose than is usual with the schistose formations and is possibly of an intermediate type.

Fig. 13.

LADY FORREST MAIN SHAFT.

CROSS SECTION.



Schistose Lodes in the Quartz-Dolerite Greenstones.—Lodes of this type are but poorly represented in the quartz-dolerite greenstones, probably the only one being that on the north-eastern slope of Mt. Gledden, in the Maritana G.M. Here, also, examination has been confined to the oxidised zone. Fair values were obtained above the 75ft. level from the main shaft, but how much of this is due to secondary impregnation is impossible to say. A number of cross quartz veins of the usual type were associated with this lode, which, in the oxidised zone, was rather ill-defined. It contained seams of ironstone and quartz, apparently with traces of copper. A good deal of pyrites appears to have been associated with the formation.

It is possible that some of the N.N.W.-S.S.E. striking shear zones in the Hannans Hill and Cassidy's North may be lode formations of this type, but examination below the zone of oxidation is necessary to determine that; they do not appear to carry values except those due to secondary impregnation, and are found to fault the cross quartz veins and, moreover, are closely associated with the N.S. shear zones, so that, on the whole, I am inclined to regard them as belonging to that series in spite of the fact that their strike agrees with that of the lodes. No doubt the compressive stresses that caused the shearing along the N.S. lines, also found relief in the direction of the older lines of weakness.

Schistose Lodes in the Actinolite-Zoisite Amphibolites.—The only formations seen in the actinolite-zoisite amphibolites were two small parallel ones in the dolerite derivatives in the Hidden Secret North. They occur along the same line of weakness as the Hidden Secret lodes, and at their northern end join the previously mentioned N.E.-S.W.-striking jasper. They consisted of a few lenses of flinty brown quartz in a comparatively narrow sheared zone, and were apparently too low in grade for profitable mining.

Schistose Lodes in the Dolerite Greenstones.—In this portion of the field these lodes are best developed in the dolerite greenstones. Both the Hidden Secret and the greater portion of the Fair Play lode channels occur in these rocks. In the former mine there are two main lines of lode, which may be termed the "Hidden Secret" and the "Hidden Secret South" lodes respectively; both are found to branch—the former at its northern end, the latter at its southern.

The rich shoot of ore worked on this mine—in the Hidden Secret lode—has been stoped out, and the writer can give no description of the characteristic minerals from personal observation. Mr. Simpson,* however, gives an analysis and description—in addition to two micro-photographs (plate 15)—of a block of specimen ore from this mine; he states that it was a dark green schistose rock, characterised by a very low percentage of carbonates but unusually high in pyrite, usually well crystallised; extraordinarily large quantities of gold, silver, and tellurium were also present; notable, also, was the large amount of chromium and vanadium mica. Chalcopyrite and the tellurides hessite (Ag_2Te) and petzite ($Au_2Te, 3Ag_2Te$) were also present. Mr. Simpson states that the analysis "was made on a single block of specimen ore of about five pounds weight, and the results may not be typical of the whole ore body." Other tellurides recorded from this mine are coloradoite ($Hg Te$), tetradymite ($Bi_2 Te_3$) and altaite ($Pb Te$). Although in the specimen quoted but little carbonate was present, the country rock in the vicinity of the lode is fairly highly carbonated, and numerous veins —sometimes across, sometimes with the shear-planes—and irregular patches of carbonates were observed in the lode channel; a fair proportion of the carbonate is evidently calcite, from its strong effervescence in cold HCl; these carbonates were sometimes associated with milky quartz. In the altered country in the vicinity of the channel crystals, probably of dolomite, up to one-sixth of an inch in size were developed in places. Some thin lenses of flinty quartz also occur in the lode. Fuchsite was occasionally noticed in the vicinity of the quartz and carbonate veins. A good deal of fine pyrite was present in the lode itself, while in the immediate vicinity there was a marked development of large cubes of pyrite—specimens of over half an inch square being obtained by the writer.

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* *Loc. cit.* pp. 68 and 71.

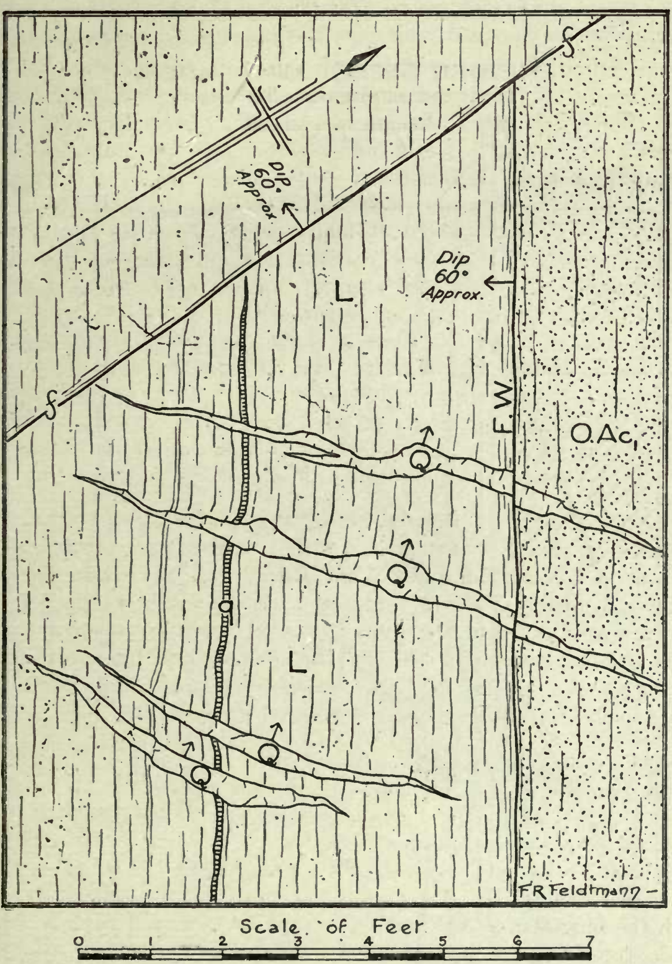
Noticeable in the west branch of the lode at the 89ft. level was a series of short, thick lenses of milky quartz running across but within the lode and dipping to the north (Fig. 14); these are probably due to the filling of contraction cracks within the lode itself, and are of a different character to the thin auriferous cross quartz veins so characteristic of this end of the field; these latter also occur on the mine. There are a number of minor sheared zones, joints, and some small local faults in the vicinity of the lode (Fig. 15).

The rich shoot in this mine, so far as can be judged, occurred at the junction of the east and west branches of the lode, but exactly what shear planes controlled the distribution of the ore it is now impossible to say, owing to the stoping of the shoot itself and the rock in its immediate vicinity. Its form was nearly that of a pipe, or more correctly that of a greatly elongated lens (*vide* Plate VII.), with the longest axis practically vertical; it extended from a depth of 35 feet from the surface to just above the 304ft. level, where a trace of one of the shear planes along which the rich telluride ore occurred can be seen.

Other shoots of good ore, of the usual lenticular character, have been found on the mine, and I can see no reason why other payable shoots should not be found. At the 404ft. level the lode junctions with the fuchsite-carbonate-quartz body.

In the Fair Play the lenticular form of the ore shoots is most noticeable; the shoots pitch to the south, following each other very

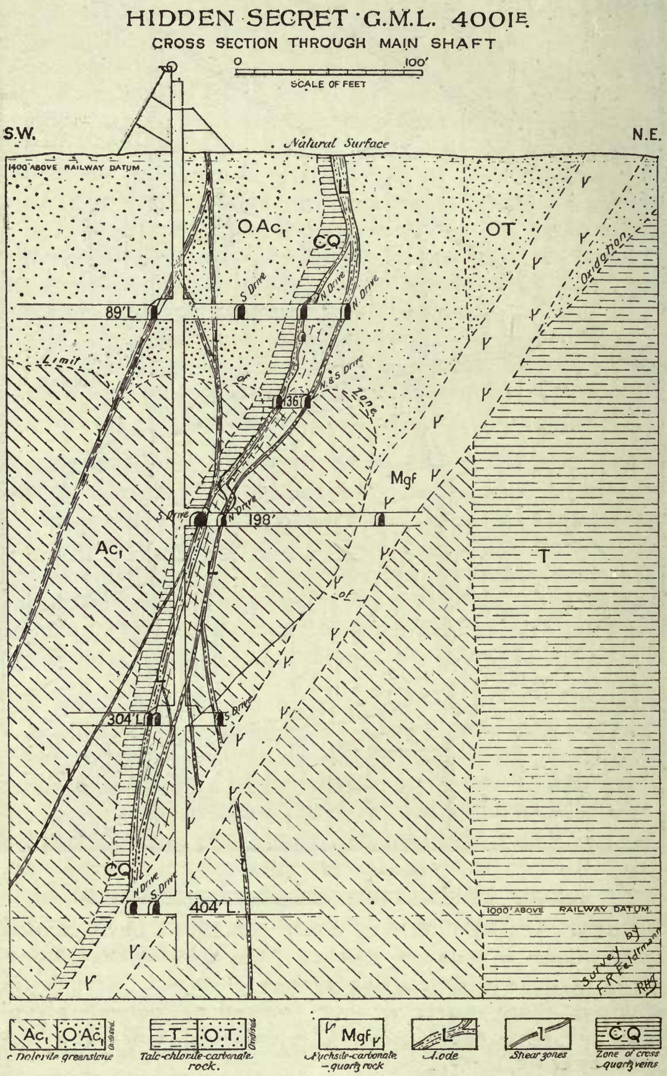
Fig. 14.



HIDDEN SECRET G.M.L 4001^E ⤳ 89 Ft Level, N. drive on W branch of lode ⤳ Sketch Plan showing cross veins of white quartz Q cutting planes of lode L, with lenses of brown flinty quartz q, but faulted by footwall plane F W, — N-S fault plane § — oxidised dolerite greenstone O Ac$_1$. ⤳

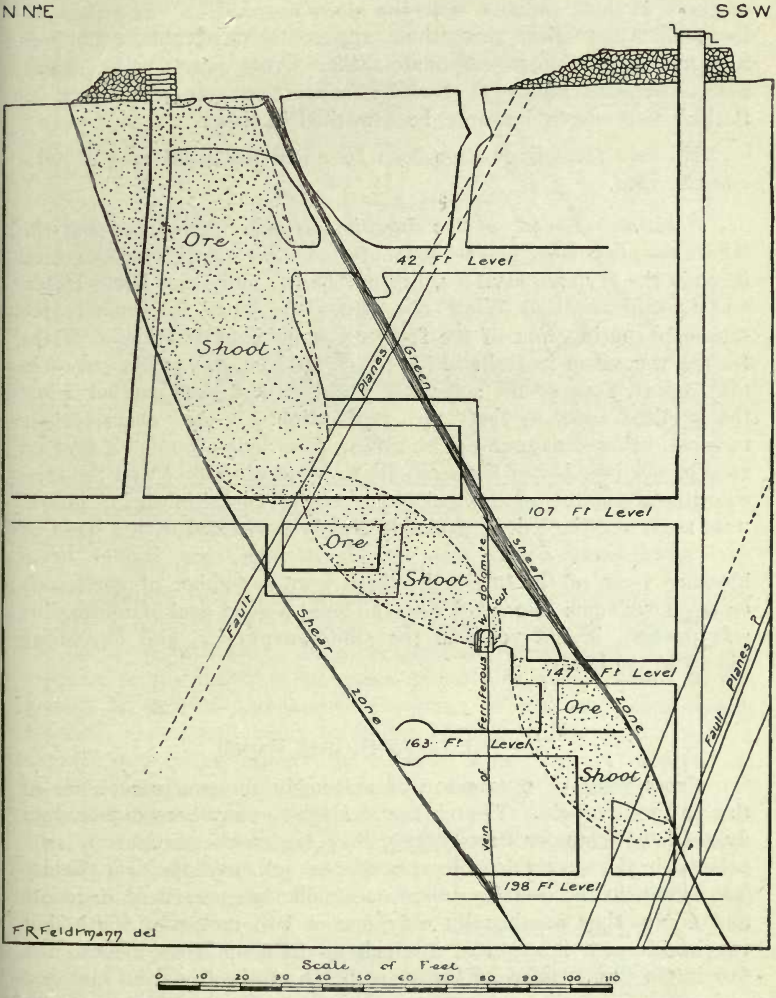
closely. The distribution of the ore seems to have been largely controlled by two more or less parallel shear or fault zones, running across the lode with a strike of about 35° north of west and dipping

Fig. 15.



west of south (Fig. 16). The more southerly and more strongly marked of the two, forming the hanging wall of the shoots, is composed of green, probably fuchsitic and talcose, schist, with some green quartz in places. Between the main shaft and the ladder way the lode splits going north and the line of junction of the two branches has probably had some influence on the ore deposition as the shoots occur close to it. The lode itself is largely composed of carbonates—

Fig. 16.



FAIR PLAY G M — LONGITUDINAL SECTION SHOWING ORE-SHOOTS.

mainly dolomite—with some sericite, quartz, finely divided pyrite, and a little chlorite, while the analysis* shows a high percentage of chromium and vanadium. Veins of dolomite, running both with and across the lode, are common, and there are some cross veins of quartz and a few seams of pyrite. Tellurides, said to have been petzite and calaverite, have been found in this mine, and some blende was observed at the 162ft. level.

Schistose Lodes in the Talcose Rocks.—No lode formations were observed by the writer in the hornblendites, and, with the exception of those at their junction with the albite-porphyrites—described below—and a few minor formations, apparently unpayable, none were seen in the talc-chlorite-carbonate rocks. Cross quartz veins, chiefly associated with bands of fuchsite-carbonate-quartz rock—such as Smith's lode—have, however, been worked in them.

No lode formations have been found in the small area of talc-mesitite rock.

Schistose Lodes at the Junction of the Greenstones and the Albite-porphyrite.—The best examples of these are the lode running through the Hyman, Mystery, Little Wonder, and Lone Hand leases, and that in the Red White and Blue—the latter is probably the southerly continuation of the former. A detailed description of the former was given in Bulletin 51, pp. 19 and 20, q. v. As stated in that report, none of the accessible workings had been carried below the oxidised zone, so that no description of the characteristic minerals below that zone can be given. This lode occupied a sheared zone at the junction of the main albite-porphyrite dyke and the talc-chlorite-carbonate rock; occasional lenses of fuchsite-bearing quartz were seen, and the lode is probably closely associated with a band of fuchsite-carbonate-quartz rock, which in this case, would be a bleached form of the talc rock; there were a number of auriferous cross quartz veins associated with the lode; a good deal of tourmaline was present, in flat veins in the albite-porphyrite, and on shear planes in the latter.

B.—THE CROSS QUARTZ VEINS.

Cross veins of quartz are of extremely common occurrence at this end of the field. Though found almost everywhere in the main dyke of the Younger Greenstones, they are most particularly developed in the quartz-dolerite greenstones, and, perhaps to a slightly less extent, in the dolerite greenstones. Though persistent in length and depth, they are usually only one or two inches in width, but varying from a fraction of an inch up to about four inches. A few in the fine-grained amphibolites north of the Sir John and east of the Broad Arrow Road were seen with a width of two feet, also one south of the Hannans Find (Fig. 17), but these were exceptional. In some instances these veins occur as vein systems rather than simple veins.

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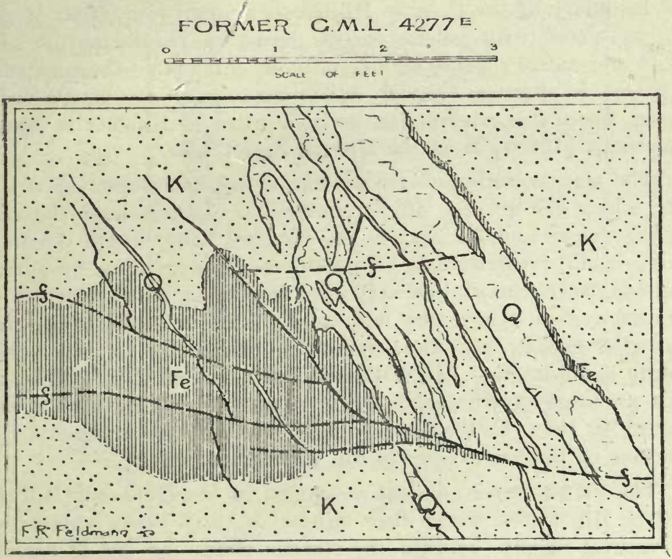
* Bulletin No. 42. Table III., G.S,M., 10847A.

Fig. 17.



Showing compound cross quartz veins – Q in oxidised epidiorite (group a) now represented by kaolinised matter – K and ferruginous matter Fe some local faulting § has affected the stringers

There are two series of these veins, the one striking approximately E.N.E.-W.S.W., with a dip usually varying from 60° to the north to verticality, the other striking more nearly E.-W. and dipping to the north at an angle, usually between 30 and 40 degrees. In general appearance the veins of the two series closely resemble each other, being composed of milky-white quartz, with a slightly oily lustre. Below the oxidised zone they are "frozen" on to the country rock, which is usually altered to a bleached, pyritic, carbonate-quartz rock—"bleached greenstone"—for a short distance from the vein (*vide* Fig. 1); the pyrite, which is fairly coarse, is usually thickest close to the veins, occasionally occurring in them. Both series carry good values; there being little to choose between them in this respect—the veins of the one series being the better in one mine, those of the other in another. The gold is free and usually coarse. In one specimen [2772], collected by Mr. W. D. Campbell from the 500ft. level of the "Reward" shaft on G.M.L. 97E, two tellurides, a pale and a dark variety, occur in the quartz; these were present in too small amounts for accurate determination, but the paler variety was most probably calaverite, the darker petzite. Tellurides are also said to have occurred in a cross vein in the Fair Play Extended. These are the only occurrences of tellurides in these veins recorded, and are important as showing that the fissures were most probably filled at the same time as the sheared zones along which the lode formations were formed. In another vein, on the south-east boundary of the Cassidy Hill lease, a small rich patch of gold was associated with galena, coarse hæmatite pseudomorphs after pyrite and coarse patches of a ferriferous carbonate—the occurrence of galena is unusual; the only other instance, so far as the writer knows, where this mineral has been recorded at Kalgoorlie, was in a specimen [**10956**] from the Hidden Secret lode.*

The steeper series of cross veins is best developed in G.M.L. 211E, where the average dip is about 70°. In this lease the veins are very close together and in the oxidised zone, where the intervening country carries low values due to impregnation by surface solutions, both veins and country have been taken out together on the open cut system, over a very large area. Further south, in the Hannans Hill G.M.L. 97E these veins are practically vertical or dip slightly to the south. In the Bonnie Lass, east of G.M.L. 211E, the veins are nearly vertical and the occurrence of vein systems is common (Fig. 18). In the Cassidy Hill, south of the Hannan's Hill, the veins of this series usually dip south at about 80°.

The flatter series are best developed in the Hannan's Hill and Cassidy Hill leases, where they appear to carry better values than the vertical veins; as with the steeper series the dip is variable (*vide* Plate VIII.), but as already stated, usually between 30° and 40°. Two veins which appear to belong to this system, but differ somewhat in strike, occur, one at the southern end of the Hannan's Hill, where it has been worked from a shaft connecting with the southernmost west crosscut—west of Brownsword shaft—at the 80ft. level; the dip of this vein is very shallow (about 12°), and the strike about 30° north of west; the other is in the Cassidy Hill lease at the end of the west crosscut from No. 1 shaft at the 55ft. level (*vide* Plate VIII., the "19dwt." vein)—the dip of this vein is about 45° and the strike about 24° north of west.

Although the two series of fissures in which these veins were formed were filled at the same time, they appear to have originated at different periods. The steeper series seems to have been the earlier, being apparently faulted in places by the flatter. The former series strikes at right angles and appears to be complementary to the sheared zones of the lode formations.† The flatter veins, on the other hand, most probably represent a series of overthrust faults resulting from pressure from the north at a later period than the

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*** Bulletin No. 42, p. 93.**

† Bulletin No. 51, p. 22.

probable W.S.W.-E.N.E. pressure which caused the shearing along the lode channels and the fissures of the steeper veins. Both series were probably filled after a period of relaxation, following on the period of compression, had opened the fissures to some extent.

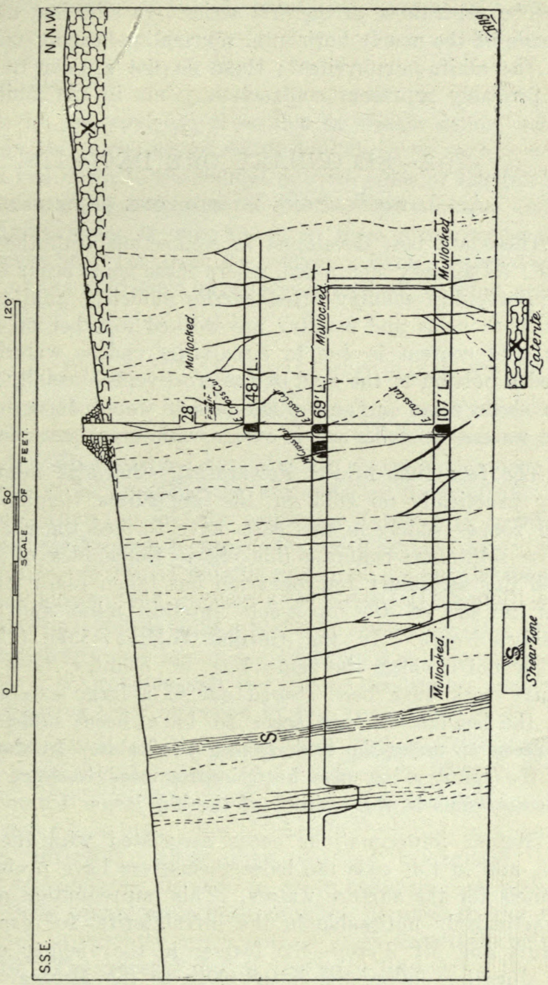

Fig. 18.

BONNIE LASS G. M. L. 796 E.

LONGITUDINAL SECTION SHOWING SYSTEM OF CROSS QUARTZ VEINS.

Although these veins have been worked to such an extent in the oxidised zone, comparatively little work has been done on them below that zone, although they maintain their values at depth; since, as already stated, being frozen on to the country rock and, where close together, the intervening country having to be taken out as well, much greater labour and expense are entailed than in the oxidised zone.

In addition to the veins of these two series, others of fairly similar character occur, sometimes striking with the country, sometimes across it—the dip of these varies considerably—they may be connected with those of the first series. In addition, mention should be made of the nearly horizontal tourmaline-bearing veins associated with the albite-porphyrites*; these do not appear to carry values and probably represent contraction joints in the albite-porphyrite.

2.—SECONDARY ORE DEPOSITS.

A.—IMPREGNATIONS IN THE ZONE OF OXIDATION.

These are best developed in connection with the cross quartz veins As already mentioned, where these veins occur close together, the intervening country often carries sufficient gold to be payable when both veins and country are worked together on a large scale. This gold content is due to circulating vadose waters having dissolved a portion of the gold of the cross veins—usually in the vicinity of a shear zone or fault plane which would form a channel for these waters—to redeposit it over a wide area near the surface.

The fact that in the Reward-Mt. Charlotte mine the leaders carry practically no gold in the immediate vicinity of the N.S. shear zones—which, in this case, have formed the channels for the vadose solutions—confirms this view. Some idea of the extent to which this secondary impregnation has taken place may be formed from the size of the open-cuts in this mine and the adjoining Cassidy's North. In the Gordon G.M.L. 4539E (Cunard mine), further north along the same line of country, both leaders and country rock have been stoped out to a large extent, but in this case the leaders do not seem to have been sufficiently rich or numerous to make the undertaking profitable. In the Devon Consols the country has also been impregnated to some extent round the cross veins in the vicinity of the big jasper formation.

Similar impregnations occur associated with the lode formations, and in this case the lodes themselves have probably acted as channels for the surface waters. This impregnation near the lodes is particularly noticeable in the infralaterite, for example, at Mt. Ferrum and Mt. Percy—the former in the vicinity of the Brown Hill Junction lodes—the latter close to the Mystery lode: in the latter case there were also a number of auriferous cross veins present.

It is probable that much of the so-called "alluvial" gold within this area has been deposited by these vadose waters.

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* Bulletin No. 51, p. 19.

B. DETRITAL DEPOSITS.

(a) *Eluvial Deposits.*

These are due to the weathering *in situ* caused by the action of wind, rain, and changes of temperature at the surface. Such deposits are found in the immediate vicinity of outcrops of lodes and quartz veins.

(b) *Alluvial Deposits.*

True alluvial deposits, *i.e.*, those due to stream action, are not common within this area, being confined to the few narrow watercourses which run down to the valleys on both sides of the Intrusive Greenstone dyke, while, owing to the gentle slope of these and the fact that running water is only found in them after heavy rains, the gold is never very far from its source. Even in these watercourses some of the gold may have been deposited by wind action.

IV.—EVIDENCES OF DYNAMIC ACTION.

The compression and tension to which the earth's crust has been subjected from the earliest times in the effort to accommodate itself to the lessening surface area due to contraction, must have greatly affected rocks of such vast antiquity as those of the Kalgoorlie region. That the area in which the Kalgoorlie auriferous belt is situated has formed a general line of weakness along which these earth-movements found relief is evidenced, not only by the lodes themselves, but also by the number and variety of sheared zones, faults, etc., which are found within the area covered by this report. Some of the schistosity and jointing is probably due to local agencies —for example, it is probable that the Older Greenstones underwent some shearing during their intrusion by the Younger series.

The sheared zones of the lodes and jaspers (or graphitic schists) were evidently the result of pressure in a W.S.W.-E.N.E. direction. In this area these compressive stresses seem to have found relief along four main lines of shearing running in a general N.N.W.-S.S.E. direction; these lines are not continuous, being broken for a considerable distance in some instances; in addition, minor shear lines occur, sometimes roughly parallel to the main lines, sometimes apparently representing cross fractures between two main lines. The general dip of the main lines is to the west at a steep angle.

The westernmost line is represented by the Golden Zone and the westernmost of the Golden Dream lodes; south of the latter there is apparently a big gap, south of which this line is occupied by the series of jaspers and graphitic schists running between the Reward-Mt. Charlotte leases and Williamstown. East of this first line is a second, occurring along the eastern edge of the main albite-porphyrite dyke, and now represented by the Mystery and Red White and Blue lodes; south of this, this line is occupied by two small barren lodes in the Hidden Secret North, and further south by the Hidden Secret and Hidden Secret South lodes. At this end this line is joined by the third and probably the longest and strongest line, represented by the main jasper running from beyond the northern limits of the map through the Sir John, Ivy, Devon Consols, and other leases to a point south of the Bulong Road. Further south this line is occupied by the band of fuchsite-carbonate quartz rock running through the Hidden Secret leases. At its northern end the fourth line runs towards the third, north of the North Collier; south of this lease it appears to be broken for a short distance and is then occupied by the Westralia United line of lode, running from north of the Kanowna Road nearly to the Bulong Road; then comes the roughly N.-S. formation of the Isabel, Creswick, and A.W.A. United, with its numerous spurs. If the second and third lines continued further to the south they would run into the fourth south of the A.W.A. United.

Those results of dynamic action, other than the sheared zones of the lodes and graphitic schists, may be separated for convenience into:—

(a) The barren N.-S. shear zones, and

(b) The faults.

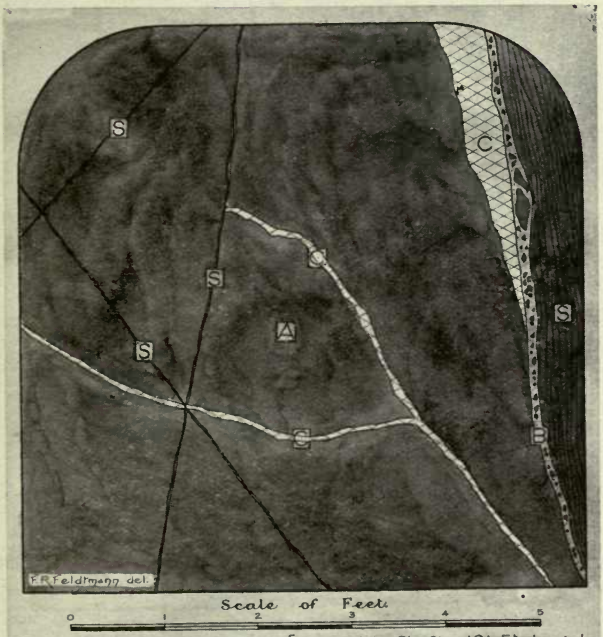
(a) *The Barren N.-S. Shear Zones.*

An extensive series of these shear zones is found running through the Hannan's Reward-Mt. Charlotte leases, in quartz-dolerite greenstone. In strike they are practically N.-S., and the usual dip is to the west at a steep angle. In the above-mentioned mine there are two main lines, about 200 feet apart, the westernmost of which may, for convenience, be termed the "Charlotte shear zone"; the easternmost, the "Reward shear zone." A number of subsidiary lines of shearing and faulting run between them, sometimes roughly parallel, sometimes running diagonally from one to the other (*vide* maps and Plate IX.).

The Charlotte shear zone varies in dip from 60 to 80 degrees, but usually dips at about 70 degrees. The Reward shear zone is steeper, being vertical at the lower levels, but dipping to the west at about 70 degrees, or a trifle more, near the surface. Running into the latter near the southern end of G.M.L. 97E are two parallel shear zones, about 120 feet apart, striking about N.W.-S.E. and dipping south-west at from 50 to 60 degrees; whether these resulted from the same stresses as the N.-S. shear zones, or are older formations which were further sheared at the period when the latter were formed, it is impossible to say owing to the inaccessibility of the deeper levels of the mine, but I am inclined to the former view. In the Cassidy Hill mine, in the angle between N.-S. and the N.W.-S.E. shear zones, the country is much shattered and jointed, and there are a number of small N.-S. fault planes (Plate VIII.). Another well defined N.-S. shear zone occurs in the Lord Nelson G.M.L. 4477E; this dips west at about 75 degrees in the upper levels, but is practically vertical between the 191ft. and the 290ft. levels.

In the oxidised zone these shear zones greatly resemble the schistose lode formations in general appearance, but the N.-S. strike and the fact that they fault the cross quartz veins serve to identify them. Below this zone, examination shows an absence of the marked metasomatism characteristic of the true lode-formations, the shear zones being represented by a band of schistose and sometimes brecciated rock, associated with a few white carbonate veins (Fig. 19).

Fig. 19.



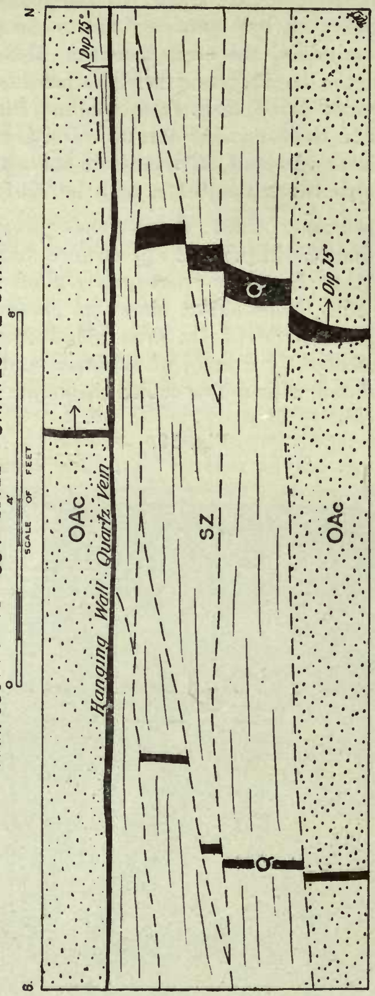
LORD NELSON G.M.L. 4477E Main Shaft, 191 Ft Level. Face of N. Drive showing Shear Zone in quartz-dolerite amphibolite A, with brecciated zone B, planes of shearing S, and carbonate veins C,

The evidence as to the relative movement of the rocks along these shear zones is unsatisfactory. As seen in plan (Figs. 20-25)

Fig. 20.

G.M.L. 211 E.

MAIN SOUTH DRIVE 95 FT LEVEL "CHARLOTTE SHAFT"

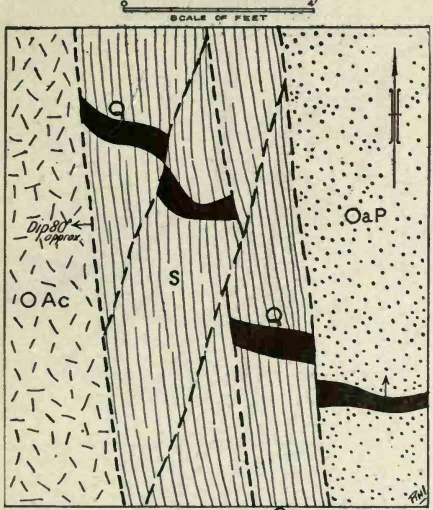


Showing faulting of Cross Quartz Veins —Q along N. & S. planes in Shear Zone —SZ in quartz-dolerite greenstone (Oxidised) OAc.

the cross veins have been thrown to the north, going west; if the movement was vertical, then the downthrow was on the eastern side. One instance of movement in the contrary direction was seen in the north drive on the graphitic schist at the 290ft. level from the Charlotte shaft (Fig. 22), where a quartz vein was apparently thrown to the north going east—this looks like local block faulting. Striæ were visible on the shear planes only in a few instances: some appeared to pitch diagonally to the north, others were horizontal; as there may have been subsequent local movements this evidence is unsatisfactory.

Fig. 21.

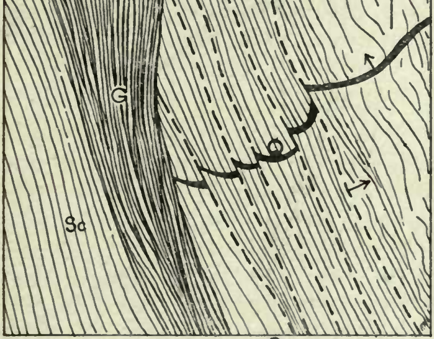
G.M.L. 211E.
5TH DRIVE OFF MAIN E. CROSSCUT 95 FT LEVEL
"CHARLOTTE SHAFT"



Sketch Plan showing faulting of cross quartz vein - Q (which cuts planes of ← schistosity) by planes of N-S shear zone - S at junction of quartz-dolerite = greenstone (oxidised) O Ac and probable albite-porphyrite (oxidised) O aP

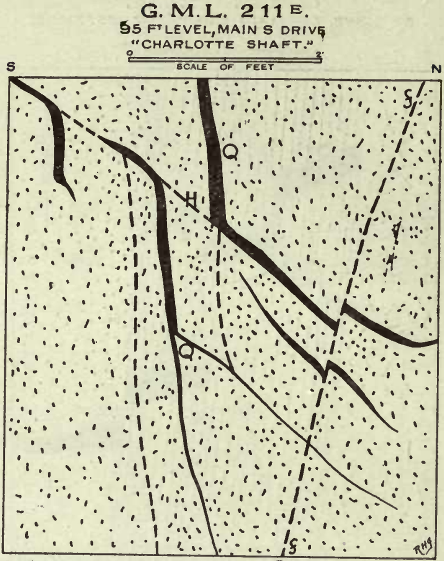
Fig. 22.

G.M.L. 211E.
NTH DRIVE OFF MAIN E. CROSSCUT 290 FT LEVEL.
"CHARLOTTE SHAFT"



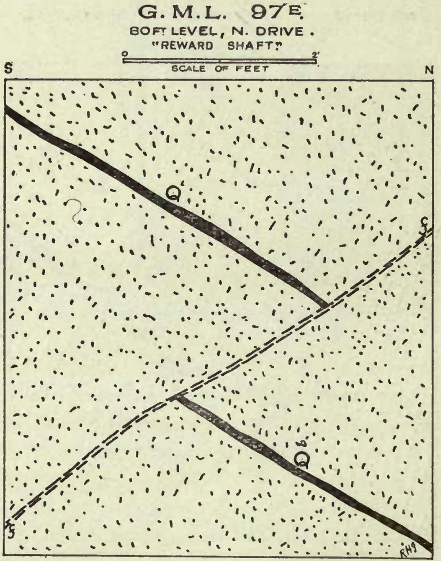
Sketch Plan showing faulting of cross quartz vein - Q in opposite direction to that of figs 20 & 21 ScC - sheared carbonate quartz-sericite rock G - graphitic schist
Sc - grey carbonate - quartz - sericite schist

Fig. 23.



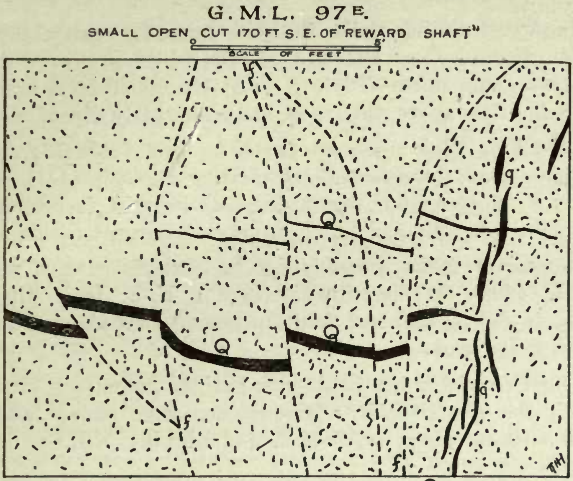
Section looking W. showing cross quartz veins - Q turning along "head" H but cut by fault §.

Fig. 24.



Section looking W. showing overthrust faulting of cross quartz vein - Q by E.-W fault plane.

Fig. 25.



Sketch section looking N.W. showing faulting of flat cross quartz veins – Q by vertical faultplanes f also vertical series of quartz lenses q.

It is highly probable that the compressive stresses which caused the N.-S. shear zones caused further shearing along the lode channels, with faulting of the adjacent cross veins, such as can be seen in the Hidden Secret and other mines.

(b) *Faults.*

The most important series of faults within this area is one striking S.S.W.-N.N.E. and best represented in the Golden Zone group of leases.* The faults of this series are either vertical or dip steeply to the north, and throw the lodes to the E.N.E. going north; the horizontal component of the movement is greatest at the surface, where it varies usually from 65 to 120 feet, but being only five feet in the case of a small subsidiary fault near one of the main ones. The movement in most instances appears to die out at a depth varying probably between 300 and 700 feet from the surface.

The fault in the Mystery mine affecting both the lode and the albite-porphyrite dyke belongs to this series, which appears to have resulted from pressure from a S.S.W. direction.

Examples of another series of faults striking nearly E.-W. and dipping south at about 30° were seen by the writer in G.M.L. 97E, where they fault the cross veins (Fig. 24), in the Cassidy Hill lease—where the movement, in one instance, appeared to be to the east, going north—and in the former Eaglehawk United G.M.L.

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* Bulletin No. 51, pp. 23-4 and Plate III.

3770E. These appear to be overthrust faults resulting from pressure from the south.

A fault with similar strike, but with generally vertical dip occurs in the Mt. Ferrum Consols G.M.L. 4230E, where it throws the lodes to the west, going north (Plate X.); at the 199ft. level and on the eastern side of the drive, this fault had a southerly dip of about 65°.

In the Fair Play mine, at the 107ft. level (*vide* Fig. 16), two fault planes about four feet apart, striking N.N.W.-S.S.E. and dipping E.N.E. at about 65°, throw the lode about 4 feet to the west, going north; other similar faults apparently occur on this mine.

Other minor faults, possibly due to local movements, were seen in G.M.L. 4499E, Williamstown, where a N.-S. fault dipping at from 45° to 60° to the east faults a quartz vein about 6 inches to the north going east.

In the Creswick mine, in the fine-grained greenstone at its junction with the quartz-dolerite greenstone, some small faults were observed striking about N.W.-S.E. and dipping N.E.

V.—THE PROCESSES OF ALTERATION.

In a report of this nature a detailed discussion of the various processes by which alteration of the original rocks has been effected is impossible. A brief account, however, may be given of the main types or degrees of alteration which may be classified as follows into those involved in the formation of—

(a) The amphibolites.
(b) The greenstones.
(c) The bleached greenstones.
(d) The lode formations.
(e) The graphitic schists.

(a) In the main, dynamic action in the form of intense pressure is the agent most chiefly concerned in the formation of the amphibolites, resulting in the formation of uralitic hornblende and saussurite (epidote, zoisite, etc.) at the expense of the pyroxenes and plagioclase felspars of the original rocks. A certain amount of contact action, however, was apparently the cause of certain features such as the spheroidal structure in some of the fine-grained amphibolites and greenstones in the vicinity of the Younger Greenstones.

(b) The processes involved in the formation of the greenstones are somewhat obscure, but it is probable that it is mainly incipient vein-alteration resulting from the widespread action of the highly carbonated, potash-bearing solutions to which the formation of the lodes is due. Whether this alteration was effected on the original rocks or on the amphibolites is difficult of proof, but owing to the long-continued pressure to which the rocks of this particular locality must have been subjected prior to the introduction of the auriferous solutions, I am inclined to think that uralitisation of the greater portion of these rocks, at any rate, must have preceded the carbonation.

Thomson,[*] discussing the relationship of the "porphyries" (albite-porphyrites) and porphyrites to the quartz-dolerite series, lays stress on the importance of the part played by albitisation in the formation of the greenstones, and considers that[†]

> "Albitization and the concomitant processes that gave rise to the greenstones constitutes the incipient vein-alteration, extreme carbonation and sericitisation with minor silification, the final vein-alteration."

On this point the evidence afforded by analyses is contradictory. Analyses of some of the greenstones show an even smaller percentage of soda than do those of the amphibolites, although their potash content is slightly higher; others, however, show an increased soda percentage up to as much as double that of the amphibolites—these last greenstones are in fairly close proximity to an albite-porphyrite dyke—the latter is carbonated in places and the carbonated variety shows a marked decrease in soda (Table I., No. 3), which may account for the increase in some of the greenstones. A complete examination of the Golden Mile is necessary before the question of albitisation can be finally settled. It certainly looks as though a certain amount had taken place in the vicinity of and resulting from the albite-porphyrite intrusions; on the other hand, saussuritisation, with the production of secondary albite, is characteristic of the amphibolites, and most of the albite in the North End greenstones at any rate is probably the result of this. Thomson states[‡] that the rocks from which the greenstones were derived were, on the whole, more siliceous than those now represented by the amphibolites. Whatever is the case on The Mile, analyses show that this is not so at the North End.

(c) The bleaching of some of the greenstones marks a further stage in the process of vein-alteration, marked as a rule by a slightly increased percentage of CO_2, and a considerable increase of potash and sulphur with the resultant formation of sericite and pyrite at the expense of the former ferro-magnesians, and possibly the replacement of some of the leucoxene by pyrite; a fair percentage of boron is also present at times.

(d) The lode formations represent the final degree of alteration with, in the case of the quartzose lodes, marked increase of silica in the central portion of the lode; in the case of the Fair Play and Hidden Secret shoots, the reverse seems to have taken place. Most, if not all, of the increased silica in the quartzose lodes is probably due to concentration of secondary silica resulting from the alteration of the ferro-magnesians. In the case of the exceptions mentioned above, much of the secondary silica has probably been concentrated in the cross quartz veins. The most important feature of this final stage of alteration was, of course, the increased amount of gold, silver, and tellurium.

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[*] *Loc. cit.*, p. 663, *et seq.*

[†] *Loc. cit.*, p. 668.

[‡] *Loc. cit.*, p. 673.

(e) The changes involved in the formation of the graphitic schists have already been discussed, and need not be further described.

VI. THE RELATIVE AGE AND RELATIONSHIP OF THE ROCKS.

(a) *The Older and Younger Greenstones.*

Putting aside for the present the discussion of a possible magmatic relationship between the rocks of these two series, we will consider the question of their relative age. On this point the evidence afforded by this area is very meagre, the exposures of apparent junctions between the rocks of the two series being, as already stated, exceedingly few and confined to the zone of oxidation. Thomson's remarks as to the possibility of the fine-grained series being regarded as chilled margins of the coarser grained series have been quoted on a previous page, and the evidence afforded by the maps as to the extent of the former series confirms his views. Moreover, the apparent contact metamorphism of some of the fine-grained amphibolites near their junction with the intrusive series, and the occurrence of quartz-dolerite amphibolite on the dump of the water-shaft on M.L. 105E, well inside the main mass of the fine-grained greenstones—in all probability a dyke intrusive into the latter—point to the fact that the original quartz-dolerite and allied rocks were later than, and intrusive into, the lavas from which the fine-grained series were derived.

(b) *The Members of the Younger Greenstone Series.*

The evidence on this question is by no means as complete as could be desired, but what there is appears to be in favour of the view that the members of this series were intruded rather as one dyke in which differentiation had taken place prior to its intrusion and solidification, than as a series of dykes, of different composition, derived from the same magma but with an interval of time between each. In general, the rocks of the various groups appear to merge into each other—direct field evidence on this point being afforded by some of the mine workings; moreover, microscopic examination points to the presence of intermediate varieties, although, the rocks being somewhat altered, this evidence is not conclusive; in no instances were the rocks of any one type seen to occur as dykes in those of another type. At other mining centres as, for instance, Bulong, gabbros—and amphibolites derived therefrom—are found to be intimately associated with serpentines which the determination of typical specimens shows to have been derived from augite-peridotites; the two rocks can frequently be seen on the one hill apparently merging into each other, and in no instance did either rock appear to occur as a dyke in the other, whereas dykes of hornblende-porphyrite were frequently seen intruding both. Unfortunately it has not yet been possible to microscopically examine a number of rocks collected from this locality by the writer, which might throw a good deal of light on this matter. On the whole, the evidence cannot be regarded as conclusive, although what there is is distinctly in favour of the intrusion of the Younger Greenstones as one dyke.

(c) *The Younger Greenstones and the Porphyrites.*

With the exception of the previously mentioned specimen of hornblende-porphyrite collected by Mr. Campbell from a shaft north of the Hyman North, and evidently from a dyke in the quartz-dolerite greenstones, no evidence is afforded by the North End as to the relative age of the hornblende-quartz-porphyrites and the Younger Greenstones. At Bulong, however, hornblende-quartz-porphyrites exactly similar to those of Kalgoorlie are found as dykes in the gabbros, amphibolites, and serpentines corresponding to the Younger Greenstones of Kalgoorlie, and there is no reason to suppose that the corresponding rocks of the two localities are of a different age. There seems, then, to be little doubt that the hornblende-porphyrites are later than the Younger Greenstones.

As regards the albite-porphyrites, the evidence is conclusive, for they have, in several instances, been seen *in situ* as dykes in the Younger Greenstones.

(d) *The Hornblende-Quartz-Porphyrites and the Albite-Porphyrites.*

The relationship between these rocks has already been considered to some extent. Here, also, the evidence is inconclusive, but the resemblance of many local varieties of the hornblende-porphyrites at Bulong to the albite-porphyrites, and the occurrence in the Mystery and Hyman leases, at the North End, of varieties of the albite-porphyrites with well developed hornblende phenocrysts, point to a close relationship between the two rocks, and it seems highly probable that the albite-porphyrites are apophyses from the main body of porphyrite occurring to the west of the Kalgoorlie townsite.

(e) *The possible Magmatic Relationship between the various Igneous Rocks of the North End.*

As we have seen, on the balance of evidence it would appear that the Younger Greenstones were later than, and intrusive into, the Older series; also, that the porphyrites were intrusive into the former series. There remains the question of their possible derivation from the same magma. Any discussion on this point must necessarily be largely speculative.

Dr. Thomson* has suggested the possible magmatic relationship of the igneous rocks of Kalgoorlie as members of a spilitic suite, and compares analyses of the quartz-dolerite amphibolite and the albite-porphyrite with those of similarly associated rocks of Great Britain. On the other hand, later analyses of Kalgoorlie amphibolites, including those of the North End, show, on the average, a much lower percentage of soda than is shown in the analysis quoted by Thomson, so that, in the absence of further evidence to the contrary, the main group of these rocks cannot be considered as other than derivatives of normal quartz-dolerites.

As regards the fine-grained series, the only analysis made of a fine-grained amphibolite shows a comparatively high soda percentage, but the potash also is exceptionally high, and in the two analyses of undoubted fine-grained greenstones the soda is certainly not above the normal for basaltic rocks.

But, on the other hand, although there is little evidence for the inclusion of these two series in a spilite suite, the analyses of the fine-grained rocks show a marked similarity to those of the less basic members of the Younger Greenstones and suggest the possibility of a close relationship between them, although for the present this cannot be considered as anything more than probable.

With regard to the porphyrites, their frequent association with gabbros or dolerites and their derivatives, as well as serpentines, in other mining centres, certainly suggests that the former may be a later differentiation from the same magma. The fact that the Ora Banda porphyrite approaches so nearly to the greenstones in composition† certainly seems to favour this view. Harker,‡ describing the Tertiary igneous rocks of Skye, which he regards as "probable products of 'differentiation' from one common stock, viz.: a large body of fluid rock-magma initially of uniform composition and occupying an intercrustal reservoir at some unknown but very considerable distance beneath the surface."§
shows that—

"igneous activity has manifested itself successively under three different phases, the Volcanic, the Plutonic, and the 'Dyke Phase' or. . . . 'the Phase of Minor Intrusions.'"

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* *Loc. cit*, pp. 663, *et seq.*
† "The Mining Geology of Ora Banda," G.S.W.A. Bulletin No. 54
‡ "The Tertiary Igneous Rocks of Skye," Mem. Geol. Surv., Great Britain, 1904.
§ *Loc. cit.*, p. 416.

If the derivation of the Kalgoorlie rocks from one parent magma be assumed, the order of emission shows a fairly strong similarity to the above phases of igneous activity, for we have first the volcanic lavas—the presence of tuffs has not been satisfactorily proved—from which the Older Greenstones were derived; secondly the dolerites, gabbros and more basic members of the Younger Greenstones, which on the whole may be considered plutonic in character, although in Kalgoorlie itself remains of a former doleritic structure are more common than those of a former gabbroid; thirdly, there are the porphyrites, which do not agree so closely with Harker's third phase, excepting in the case of the albite-porphyrites—and some hornblende-quartz-porphyrites at Bulong—but are rather intermediate between the second and third phases. In addition Harker emphasises the fact that—

> "the distinct foci at which activity was from time to time localised were also the principal centres of magmatic differentiation."*

In this connection the association of gabbros or dolerites, peridotites—or their derivatives—and porphyrites at Bulong, Ora Banda, and other gold-mining centres, in addition to their occurrence at Kalgoorlie is, at least, significant.

On the whole, then, although there can be no definite proof, it must be admitted that the probability of the derivation of the Kalgoorlie igneous rocks from one parent magma is fairly strong.

VII.—SUMMARY AND CONCLUSIONS.

The Geological History of the North End.—Summarising the results of the foregoing chapters it is possible to form some idea of the probable sequence of events in the geological history of the North End. This history is necessarily incomplete, and at present it is not possible to place some of the results of dynamic action in their proper chronological order. The correct position of the probable sediments of the Phoenix brick pits is also uncertain, but if they belong to the same series as the sheared conglomerates of Binduli, etc., they were probably formed at a later date than the intrusion of the porphyrites at any rate. But owing to the uncertainty of their position and the fact that they are of little importance within this area, they are not included in the following history.

In the first place, we must regard the Kalgoorlie region as a portion of the earth's crust attempting to accommodate itself to a lessening horizontal area due to the contraction of the earth as a whole. This resulted in a long continued period of pressure during which the rocks were sheared, crushed and fractured in places. The fissures so formed would naturally form paths for intrusions and ore-bearing solutions emitted during the intervening minor periods of relaxation.

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* *loc. cit.*, p. 419.

It would appear that the earliest rocks of which we have evidence were lavas of basaltic composition probably exuded from fissures during a period of relaxation. We can form no opinion as to the original extent and depth of these rocks or of the period of time covered by their effusion, while as to what rocks constituted the surface on which these lavas were laid down there is no evidence. It is probable that these Older Greenstones more nearly represent the average composition of the parent magma than any of the later emissions from that magma, although differentiation may have already taken place to some extent.

At a later date the quartz-gabbros or quartz-dolerites and the other and more basic members of the Younger Greenstones intruded the lavas along a line of weakness having a general N.N.W.-S.S.E. strike and resulting from pressure at right angles to that direction. The Younger Greenstone intrusion appears to have produced a certain amount of contact metamorphism in the older series; this is evident in places along the eastern edge of the former; it is improbable, however, that any absorption of the older rocks took place owing to the similarity in composition of the two series. Both rocks may have been sheared to some extent round their margins.

Subsequent pressure from the same W.S.W.-E.N.E. direction produced the lines of weakness in the Younger Greenstones along which the dykes of albite-porphyrite were intruded—probably as apophyses from the main body of porphyrite.

A further period of intense pressure from the same direction shortly after the intrusion of the porphyrites, resulted in the shearing of the Older Greenstones, Younger Greenstones and the albite-porphyrites along the four main lines mentioned in Chapter IV. with numerous minor fissures, including those at right angles and complementary to the main shear lines.

At a somewhat later period further pressure, this time from the North, resulted in overthrust faulting along E.W. lines with a shallow northerly dip.

During the long continued period of compression the Greenstone rocks were uralitised and saussuritised.

Following on the last mentioned period of pressure from the north, highly active solutions and vapours, containing boron, sulphur and carbon compounds—the latter probably a hydrocarbon—and perhaps some potash, forced their way along some of the N.N.W.-S.S.E. shear zones to form the graphitic schists. Closely following on these solutions came others containing enormous quantities of carbonic acid together with sulphur and potassium—probably combined as potassium sulphide—and also gold, silver and tellurium;

these resulted in the formation of the lodes and the auriferous cross quartz veins. These solutions would produce the greatest metasomatic alteration along the main shear lines with gradually diminishing alteration away from them. Bleaching, owing to the breaking up of the ferro-magnesians, with the formation of pyrite, etc., would take place to a greater or less extent in the immediate vicinity of the channels along which the solutions found their way, with the resultant formation of the bleached greenstones and the fuchsite-carbonate-quartz rocks; while the greenstones represent a lesser degree of alteration away from those channels. Carbonation probably continued over a long period, for carbonate veins are found associated with the later shear zones. It is possible, however, that these veins are due to the action of circulating vadose waters.

Earth movements continued to take place long after the formation of the ore deposits, one of the most important being the result of pressure, probably from the west, causing shearing along N.-S. lines with the formation of the shear zones of the Reward-Mt. Charlotte and the Lord Nelson and probably the re-opening of fissures along the lode channels.

Another important series of movements resulting from pressure from the S.S.W. faulted the Golden Zone and Mystery lodes, while a series of overthrust faults striking E.-W. was the result of pressure, this time from the south, the effects of this last being evident in the faulting of cross quartz veins in the Hannan's Hill, Cassidy Hill, and Eaglehawk United leases.

These later movements are not given in chronological order, there being no evidence as to their relative age.

It must be remembered that the above history is largely hypothetical, but it is that which seems most probable to the writer on the available evidence.

The Relative Economic Importance of the Rocks.—Turning to the question of the relative economic importance of the rocks, the most important point to be remembered is that, in this area, the payable lode-formations are invariably associated with the greenstones—never with the amphibolites. At the North End the quartz-dolerite and dolerite greenstones have proved of the greatest economic importance, the fine-grained greenstones ranking next; in the latter rocks the lodes are, on the average, poorer and more patchy. The albite-porphyrites have not, so far, proved to contain payable lodes —although lodes in which rich patches occur are found at the junction of these rocks with the Younger Greenstones, but the fact that the auriferous solutions have in all probability been after-emanations from the magma from which these rocks and the hornblende-porphyrites were derived makes them of very great significance so far as the occurrence of payable lodes in other districts is concerned.

Regarding the occurrence of lode formations in the fine-grained greenstones and calc-schists—as already stated, Dr. Maclaren regards these rocks as being normally barren, and considers that the exceptionally rich ore found in them—such as that of the Oroya-Brown Hill shoot and the Eclipse lode, in the more southerly portion of the field—has travelled in solution from the quartz-dolerite to be deposited in the calc-schist along the main shear lines. Apparently, then, Dr. Maclaren regards the auriferous solutions as having a close genetic connection with the quartz-dolerite, and, therefore, that the occurrence of payable lodes in the Older Greenstones is abnormal and due to special conditions. In dealing with the fine-grained greenstones, the present writer mentioned the comparative proximity of the lodes in these rocks to the boundary of the Younger Greenstones, and, further that most are connected with the narrow and persistent formation which follows that boundary very closely; thus apparently confirming Dr. Maclaren's views. There is, however, another possible explanation, namely, that the relative proximity of these rocks to the source of the auriferous solutions, together with the position of the main lines of weakness along which these solutions travelled, determined the relative economic value of these rocks. The area now occupied by the Younger Greenstone dyke has evidently been one of weakness, most affected during the long period of earth-movements, with the result that the main lines of shearing are in these rocks, the Older Greenstones being affected to a minor degree near their junction with the Younger rocks; moreover, the junction of the two series would be a potential line of weakness. As we have seen, the albite-porphyrites have been intruded along some of the older lines of weakness in the Younger Greenstones, and if the auriferous solutions were genetically connected with the former rocks, it is most probable that they would travel so far as possible along the same channels, or along the major shear lines which had been formed near the former after the intrusion of the albite-porphyrites. The metasomatic action, with the deposition of gold, would be greatest along the main channels and least along the minor shear lines farthest away from the main lines; so that in the shear zones in those rocks—now represented by quartz-dolerite amphibolites, fine-grained amphibolites and other amphibolitic rocks—where the solutions have had least effect, the gold content would be negligible, while in the fine-grained greenstones and calc-schists the lodes would be comparatively poor and patchy. Moreover, as regards the relative richness of the North End and the Golden Mile, it is probable that the same explanation holds good, namely, that the latter locality has been more highly sheared and was more closely connected with the source of the gold-bearing solutions.

Additional evidence against the theory that the Younger Greenstones were themselves the original source of the gold, the latter being presumably held in combination by the ferro-magnesian minerals[*]—the splitting up of these permitting the dissolving of the gold with subsequent deposition in the lode formations—is that in other districts, such as the Ularring,[†] where great numbers of auriferous quartz reefs occur, the country rock is amphibolite, derived from a dolerite or gabbro apparently of the Younger Greenstone series, and even in the sheared zones in the immediate vicinity of the reefs, the hornblende has not been appreciably chloritised; so that, in that district, at any rate, this theory does not hold good. Whether such was the case at Kalgoorlie no direct proof is at present possible, but the occurrences of the Ularring district certainly afford circumstantial evidence against this theory.

VIII.—THE MINES.

MILANESE G.M.L. 4293E (Golden Dream G.M. Co., N.L.).

The northern portion of this lease was dealt with in the previous report (Bulletin No. 51, pp. 34-5), and only the southern portion of the lease, formerly held as G.M.Ls. 4219E, 4073E, 4012E, Golden Dream, and at an earlier date as G.M.L. 1620E, Elsie Conliffe, will be described here. All these leases covered the same ground, situated in the low-lying area south of the Devon Consols Consolidated G.M.L. 1121E and the Transcontinental Railway line.

The ground is largely covered by superficial deposits, and oxidation of the underlying rocks has extended for a considerable depth, but judging by its exposure in the Transcontinental Railway cutting, the greater portion of the ground is occupied by the dyke of albite-porphyrite which runs south from the Lone Hand and Mystery mines. In this lease the dyke appears to split going south, but the evidence on this point is very unsatisfactory. The most eastern portion of the lease is in dolerite greenstone.

The two eastern lodes occurring in the northern portion of the lease have been met with in the workings from a shaft about 125 feet in depth, near the western boundary of this portion of the lease, but payable values were not obtained. This shaft is connected by a cross-cut, at a depth of 105 feet, with an incline shaft about 230 feet to the north-east, put down on a large cross quartz vein dipping to the north at about 70°. This quartz vein is exposed in a costeen running between the two shafts, and is there seen to be faulted by a small N.W.-S.E. striking fault. Other cross quartz veins have been worked on this portion of the lease. Several small shafts, now inaccessible, have been put down on this portion of the lease, but nothing of importance appears to have been encountered. On the other hand, good values have been obtained in other leases along the same line from formations on the eastern side of the albite-porphyrite dyke, for instance, in the Mystery, Little Wonder, and more recently in Mr. H. Raven's Red White and Blue G.M.L. 1228E, so that it would be worth while to do further prospecting along that line.

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[*] C. G Gibson, *loc. cit.*, p. 29.

[†] G.S.W.A. Bulletin No. 60, p. 153.

Apparently the only returns from this portion of the Milanese were for G.M.L. 4073E, namely, 41 tons for a total of eight fine ounces.

GORDON G.M.L. 4539E.

This lease is situated to the east of the Broad Arrow Road, immediately south of the Kanowna Railway line and on the north-west slope of Mt. Charlotte. It was until recently held as G.M.L. 4412E of the same name (Cunard G.M. Co., N.L.), and prior to that the greater part of the ground was held as G.M.L. 4128E, Excelsior, and at an earlier date as parts of G.M.Ls. 1100E, Chandos, and 879E, Richmond.

A band of quartz-dolerite greenstone, probably averaging three chains in width, runs through the middle of the lease, the south-western portion of which is in quartz-dolerite amphibolite, and the eastern portion likewise in amphibolite, which is here more gabbroid in appearance.

The main shaft is situated near the centre of the lease in the greenstone belt. I was unable to ascertain the exact depth of this shaft, the lower levels, which were in sulphides, being inaccessible. A good deal of work had been done at and above the 95ft. level, on a number of the E.N.E.-W.S.W.-striking cross quartz veins. In this mine these veins dip north at about 60 degrees, or slightly steeper. A few of the flatter cross veins occur, but in this mine the steeper series were said to carry better values. I could see no definite lode formation, but several shear planes, following the usual strike of the country and dipping W.S.W. at angles between 50 and 60 degrees, were observed; the relationship between these and the cross quartz veins could not be distinguished.

Both veins and intervening country have been stoped out to a considerable extent, and there has evidently been a fair amount of secondary impregnation in the oxidised zone.

A fair amount of work has been done on the "alluvial" ground at the northern end of the lease.

As there does not appear to be any well-defined lode on this mine, its future prospects depend on the cross quartz veins in the narrow belt of greenstone. Judging by the work that has been done so far, these do not seem to be sufficiently close to enable them, together with the intervening country, to be treated on a large scale, particularly as the limit of oxidation is probably not far from the surface at the southern end of the lease; and the mining of the cross veins by themselves is more suited to small parties than a large company or syndicate.

At the time of my visit the treatment plant consisted of a Huntingdon mill of local manufacture.

Returns for this and former leases are as follows:—

Name and Number of Lease.	Ore treated.	Gold therefrom.	Rate per ton.
	tons.	fine ozs.	fine ozs.
Gordon, 4412E	5,138·25	557·82	0·11
Excelsior, 4128E	546·00	109·13	0·20
Quartz Claim, 234E	96·00	16·51*	0·17*
Totals	5,790·25	683·46	0·12

* Not reduced to fine ozs.

GORDON SOUTH G.M.L. 4446E (now voided).

This lease was situated south-west of and adjoining the Gordon. The country rock of the area covered by this lease is quartz-dolerite amphibolite. The northern portion of the ground is covered by superficial deposits, probably of no great depth. The unoxidised rock is close to the surface in the southern portion of the ground. One shaft had been put down near the centre of the ground of which no particulars are available; the rock on the dump, however, is amphibolite of the Warden's residence type. There are no returns for this area, and there do not appear to be any reasonable prospects of anything payable being found, though a few cross veins may possibly occur.

PRINCE FOOTE G.M.L. 4425E (voided).

The ground covered by this lease formed part of the earlier St. Mungo G.M.L. 1292E, later the Hannan's Britannia. It is situated partly in the angle formed by the Kanowna and Boulder Railway lines, close to their junction, and partly north of the former railway.

In the angle between the two lines there is a small laterite-capped rise, under which a fair amount of work has been done, and there are numerous shallow shafts on the ground. The country rock is nowhere exposed, but the western portion of the lease is possibly in the southern extension of the dolerite greenstone exposed in the Mullingar quarry; the extreme eastern portion is most probably in quartz-dolerite amphibolite. Fragments of a jasper formation were visible on an old dump beyond the western boundary of the lease and close to the Kanowna Railway line.

The gold obtained from under the laterite cap has probably been formed by secondary impregnation after being leached out of cross quartz veins. No lode formation has apparently been found in this ground.

The only returns are for G.M.L. 1292E, from which 374.5 tons of ore were treated for a return of 257.86 fine ozs.—an average of 0.69 fine ozs. per ton.

ENTERPRISE G.M.L. 4509E.

This lease lies to the east of the Gordon and south-west of the Milanese, on the northern slope of Mt. Charlotte, the southern portion of the lease covering the northern portion of the Reservoir Water Reserve. This lease and the adjoining Enterprise South are held by the Adelaide Enterprise Prospecting Syndicate, N.L., being granted conditional to there being no mining on the Reserve within 200 feet of the walls or floor of the Reservoir. The ground was formerly held as G.M.L. 4153E, £ s. d., and previously as part of G.M.L. 879E, Richmond.

The small area of gabbroid amphibolite occurring on the east of the Gordon probably runs diagonally across this lease, the north-eastern and south-western portions being in quartz-dolerite greenstone.

But little work has been done on this lease and none of the shafts were accessible. There are no signs of any lode formations in this ground, but cross quartz veins should occur.

Returns for this ground are for G.M.L. 4153E from which five tons were treated for a return of .36 fine oz., an average of 0.07 fine ozs. per ton.

ENTERPRISE SOUTH G.M.L. 4530E (Fig. 26).

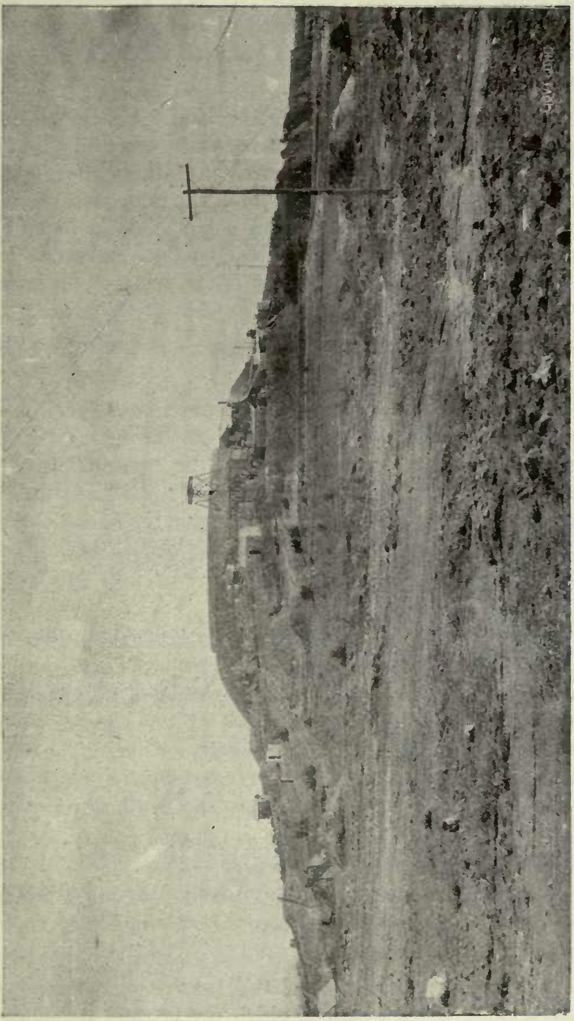
This lease is situated to the south of and adjoining the previous one and was formerly the northern portion of G.M.L. 212E, Mt. Charlotte, part of which was afterwards resumed as part of W.R. 9892.

With the exception of the extreme western portion, the lease is entirely in quartz-dolerite greenstone.

At the time of my visit work was being carried on at the south-eastern corner of the lease from the main shaft, which was 145 feet in depth, on a number of cross quartz veins similar to those in G.M.L. 211E further south. The country between them was impregnated to some extent and was being mined together with the quartz veins. There were no signs of any lode formation; and although the cross quartz veins are fairly numerous, and oxidation appears to have reached a considerable depth in the eastern portion of the lease, the future prospects are not very great, owing to the necessarily restricted mining.

Official returns up to the end of 1914 show a total of 1,901 tons treated for a return of 407.43 fine ounces, an average of 0.21 fine ounce per ton.

Fig. 26.



Mt. Charlotte Reservoir and Enterprise S. Main Shaft from S.E.

Photo: F. R. Feldtmann.

Neg. F186.

There was a Huntingdon mill worked by a suction gas engine of 22½ h.p. on the mine.

Brilliant G.M.L. 1653E. This lease, together with G.M.Ls. 97E, 160E, 211E, 213E, and 4529E, is held by the Hannan's Reward, Ltd., formerly the Hannan's Reward and Mt. Charlotte, Ltd. This lease is the northernmost of the group, and is situated south of and adjoining the Milanese and east of the Enterprise.

The two branches of the big albite-porphyrite dyke occurring on the Milanese pass through this lease, the western portion of which is in quartz-dolerite-greenstone, the extreme eastern, and probably that portion between the two branches of the albite-porphyrite, in dolerite-greenstone.

There are five comparatively shallow shafts on this lease, the middle one, Romaine's shaft, near the northern boundary, having a depth of 130 feet. On the dump of this shaft small crystals of axinite,* a borosilicate of aluminium and calcium, were found by Dr. Thomson in fragments of a quartz vein. This is the only recorded occurrence of this mineral at Kalgoorlie. A search by the present writer failed to reveal further specimens. Specimens of the albite-porphyrite were common on the dump.

The northerly continuation of a jasper outcropping on G.M.L. 213E runs through this lease.

With the exception of a shallow shaft north-east of Romaine's shaft, no work has been done near the eastern branch of the albite porphyrite. As stated when dealing with the Milanese lease, rich patches have been found on the eastern side of this dyke, and it might be advisable to do further prospecting here.

Returns for the leases held by the Hannan's Reward, Ltd., are given later.

Mt. Charlotte G.M.L. 213E. This lease is situated south of and adjoining the last, and east of Mt. Charlotte.

The western branch of the albite-porphyrite dyke probably runs through this lease slightly to the east of the middle, while the eastern branch runs close to the north-east corner. The western half of the lease is in quartz-dolerite greenstone, in which several cross quartz veins have been worked near the southern corner.

A jasper formation, apparently on the eastern side of the western branch of albite-porphyrite outcrops on the lease, Clay's shaft (v.d. 104 feet) having been sunk on it. About 460 feet of cross-cutting has been done to the west of this shaft at the 43ft. level, apparently without results.

In the north-eastern portion of the lease some alluvial work has been done along a watercourse which starts near the Kanowna Road.

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* G.S.W.A. Bull. 42, p. 134.

G.M.L. 4529E. This is another of the leases held by the Hannan's Reward, Ltd. It, together with G.M.L. 4530E, was formerly held as G.M.L. 212E, Mt. Charlotte. This lease lies to the south of and adjoining G.M.Ls. 213E, 4530E, and former G.M.L. 4446E.

The western half of the lease is in quartz-dolerite amphibolite, and the greater portion of the western half in the corresponding greenstone. The northern extension of the graphitic schist formation, and the fuchsite-carbonate-quartz rock cut in the east crosscut at the 290ft. level from the Charlotte shaft on G.M.L. 211E, probably occurs in the easternmost portion of the lease. A prominent hill at the south-east corner is covered by dense, highly ferruginous laterite.

Much of the eastern portion of the lease is now covered by slimes dumps, and apparently has not been tested. What is probably the northerly continuation of the "Charlotte" shear zone has been worked to a depth of 80 feet in a shaft about 100 feet south of the south-west corner of G.M.L. 213E, low-grade ore being obtained therefrom, evidently due to secondary impregnation from cross quartz leaders; several of the latter have been worked on the south-west slope of Mt. Charlotte.

A good deal of dryblowing has been done on this lease in the lower-lying ground.

From a point a little to the south of the southern corner of the Reservoir fence a tunnel has been driven into the mount in a northerly direction to a point under the Reservoir; nothing of value was disclosed by this tunnel.

It is unlikely that anything of value will be found in the western portion of the lease, but further prospecting in the area now covered by the slimes dumps would probably disclose other cross quartz leaders which might prove to be payable.

MT. CHARLOTTE G.M.L. 211E. This lease lies to the south of and adjoining the previously described lease.

As in the preceding lease, the western half of this lease is in quartz-dolerite amphibolite, an outcrop of the type rock occurring on the northern boundary at the back of the Warden's residence; west of this the amphibolite is somewhat more gabbroid in appearance.

Most of the eastern half of the lease is in quartz-dolerite greenstone, but on the eastern side of the last-named rock is a dyke of albite-porphyrite, sheared and carbonated in places; east of this, again, is a band of graphitic schist, while still further to the east are areas of fuchsite-carbonate-quartz rock and talc-mesitite rock (*vide* Plates III. and XI.). These rocks were met with in the previously mentioned east crosscut at the 290ft. level, and were described in detail when dealing with the graphitic schists.

The "Charlotte" or western shear zone, mentioned in the chapter on the Evidences of Dynamic Action, runs right through the leases, passing about 25 feet east of the main shaft at the surface. It can be observed in the huge open-cut near the southern boundary of the lease. In this lease the dip varies between 60 and 70 degrees. Between 180 and 250 feet east of this shear zone is the eastern or "Reward" shear zone, which probably runs into the previously mentioned albite-porphyrite dyke.

A great number of cross quartz veins of the steeper series occur on this lease; they vary from about six inches to a fraction of an inch in thickness, and as a rule carry fair values, the gold in them being fairly coarse. They are undoubtedly the original source of most, if not all, of the gold obtained from this lease, whether from the impregnated country between these veins or the alluvial gold in the lower-lying ground. In the oxidised zone these leaders are easily worked, and, in this mine, being only a few feet apart, the country can in places be profitably taken out *en masse,* as may be judged by the size of the open-cut (Figs. 27 and 28). But few of the flatter-dipping cross veins occur on this lease, though particularly common in G.M.L. 97E to the south.

The main shaft, which has a vertical depth of 496 feet, is situated about 520 feet south-west of the north-east corner of the lease, and levels have been driven at depths of 95, 190, 290, 388, and 488 feet. Crosscuts were driven east from the three upper levels, cutting the graphitic schist and fuchsite rock; the former has been driven on to the north for a considerable distance at these levels, but there is no record as to what values were obtained, though probably there was a certain amount of impregnation along this line from the cross veins.

The western shear zone has been driven on to the southern boundary at the 95ft. and 190ft. levels and for about 210 feet south at the 388ft. level. At the two former levels much work has been done on the cross quartz veins, as also at the 100ft. level from Tweedie's shaft near the north-east corner of the open-cut, chiefly on the eastern side of the western shear zone. Values are poor in the leaders in the immediate vicinity of the shear zone, which faults them to the north going west—the faulting is greatest, usually a few feet, along the hanging-wall plane of the shear zone, but the leaders are also faulted a few inches along the footwall and intermediate planes. In the sulphide zone the gold content of these veins is probably as high as in the oxidised zone, but owing to the greatly increased hardness of the country rock, and the fact that the veins are "frozen" thereto, mining is more difficult and the costs higher.

There is an old 30-head battery north of the main shaft; this is no longer in use. Mr. H. Raven, to whom the leases belonging to the Hannans Reward Co. have been sub-leased, treating the ore therefrom at his own plant on G.M.L. 796E. A winding engine is, however, in use at the main shaft.

Fig. 27.

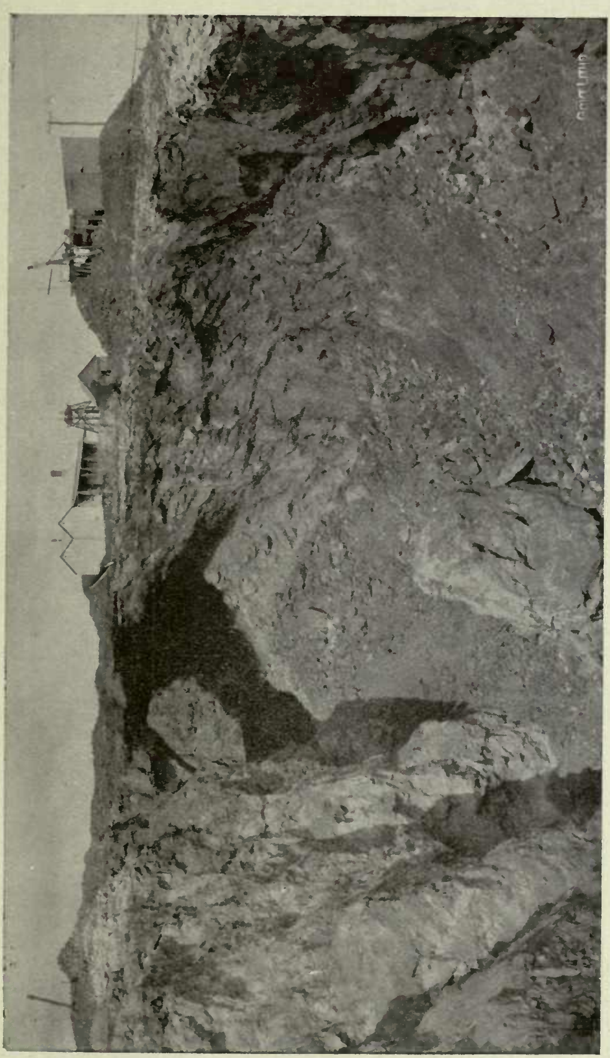


Photo: F. R. Feldtmann. **G.M.L. 211E, "Charlotte" Open Cut from North.** Neg. F192.

Hannan's Hill G.M.L. 97E (*vide* Plate X.). This lease is situated to the south of G.M.L. 211E. Like the latter, it has been let to Mr. Raven, the southern portion of the lease being, at the time of my inspection, further sub-let to Messrs. Shepherd Bros., the holders of G.M.Ls. 415E, 1163E, and 14CE.

Fig. 28.

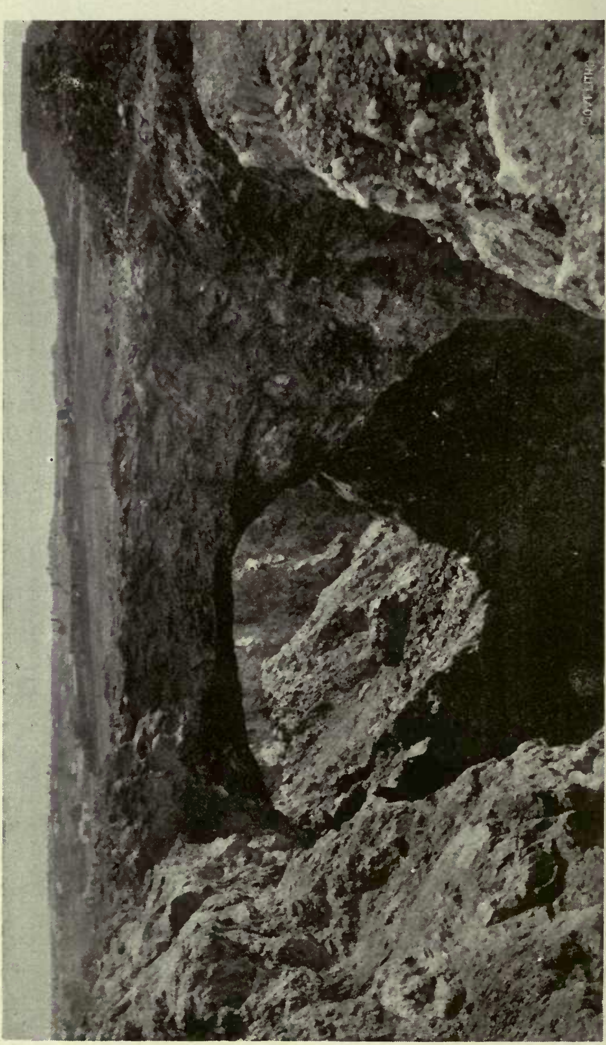


Photo: F. R. Feldtmann. Neg. F193.

G.M.Ls. 211E and 97E, looking N. from Northern Open Cut, on 97E, into "Charlotte" Open Cut.

As in the preceding leases, the extreme western portion of this lease is in quartz-dolerite amphibolite, the wide band of quartz-dolerite greenstone occupying the middle of the lease. A band of amphibolite, entirely obscured, probably lies to the east of this, while still further to the east is the band of fuchsite-carbonate-quartz rock met in G.M.L. 211E, intersected by an albite-porphyrite dyke and several lenses of jasper, probably graphitic at depth. The latter can be seen outcropping in places, near the old water-shaft.

The shear zones running through the last-mentioned lease pass through this lease also, the "Charlotte" shear zone being cut in a crosscut west from Barnfield shaft, at the 80ft. level; this shaft is situated near the south-west corner of the "Charlotte" open-cut. This western shear zone has only been driven on for a few feet in this lease, but a good deal of driving has been done on the "Reward" shear zone. East of this shear zone, and joining it immediately south of the open-cut about two chains north-east of the main shaft is another shear zone, apparently of a similar character, but striking approximately N.W.-S.E.; this can be seen in places in the open-cuts near the southern boundary of the lease and in the workings from the Cassidy N. (G.M.L. 1163E) main shaft, while a parallel shear zone, roughly two chains south-west of the last, can be seen on the western side of the open-cut on the southern boundary of the lease. Whether these N.W.-S.E. striking formations are true lodes or belong to the latter series of barren shear zones, is difficult to determine, the writer having no opportunity of examining them at depth; their strike is in favour of the former, but their general characteristics and low value in the oxidised zone, together with the fact that they apparently do not exist to the west of the N.-S. shear zones, are decidedly in favour of the latter view. Numerous minor shear zones and fault planes occur on the mine.

As in the previous lease, the cross quartz veins are the main source of the gold in this lease, but here the flatter E.-W. series predominates. Examples of the steeper series occur, but are not so common as, and are steeper in dip than in G.M.L. 211E, being practically vertical at the southern end of the lease. In a specimen [2772] from a cross vein from the bottom level of the main shaft, splashes of telluride occur associated with free gold; this is the only occurrence of tellurides in these cross veins recorded.

The main or "Reward" shaft, which has a depth of 518 feet, is situated on the top of the hill from which the lease takes its name. The workings are very extensive, levels having been driven at depths of 80, 138, 197, 295, and 493 feet; only the first three were accessible at the time of this survey. North and south drives traverse the lease from end to end at the 80ft. level, from which much stoping has been done on the cross leaders, particularly in the southern portion of the lease, where the workings resemble a rabbit warren. The eastern workings at the 80ft. level are connected by winzes with a long drive north at the 80ft. level from the Cassidy's North main shaft, the Cassidy's North 80ft. level corresponding to one of 114 feet as measured from the surface at the "Reward" shaft. A good deal of work has been done at the 197ft. level, where long drives have been put in to the north and south, the latter nearly to the boundary of the lease, following the shear zones, which were evidently regarded as true lodes.

There are numerous shallow shafts on the lease, either on the cross veins or connecting with the 80ft. level in the vicinity of cross veins. There are several large open-cuts on this lease—the northernmost connecting with that on G.M.L. 211E—in which both leaders and the intervening country have been worked on a large scale.

HANNAN'S REWARD G.M.L. 160E. This lease adjoins G.M.L. 97E, and is the southernmost belonging to the Hannan's Reward Co.; the boundary between the quartz-dolerite amphibolite and greenstone passes through the lease. There are three shafts on the lease, of which one—"Hannan's" shaft—on the northern boundary connects with the south drive at the 80ft. level from the "Reward" shaft. Opposite Hannan's shaft long crosscuts run east and west to the boundaries of the lease; the western one, which, unfortunately, was mullocked up, evidently cuts the Charlotte shear zone at about 280 feet west (along the crosscut) of the shaft.

Returns supplied by the Mines Department Statist for the leases held by the Hannan's Reward, Ltd., are as follows:—

Numbers of Leases.	Ore treated.	Gold therefrom.	Rate per ton.
	tons.	fine ozs.	fine ozs.
97E, 160E, 211E, 212E, 213E, 1653E	312,824·31	72,806·35*	0·23

* Includes 2·58ozs. specimens and dollied.

CASSIDY HILL G.M.L. 4E (Figs. 29 and 30). This lease lies to the south of and adjoining the previously described lease; its south-western boundary crosses the Boulder Railway line. Now owned by Mr. A. G. Hadden, it was formerly one of the Paringa Mines, Ltd., leases.

The eastern and greater portion of the lease is in quartz-dolerite greenstone, the western in the corresponding amphibolite, intermediate phases occurring between the two.

The Charlotte and Reward shear zones apparently pass into the lease, although the former had not been cut in any of the workings accessible to the writer; the latter is seen as a thin shear zone in the crosscut at the 180ft. level connecting the main shaft with No. 2 shaft.

The workings have disclosed no lode formations on the mine. All the gold, as with the Hannan's Reward leases, being obtained from the cross quartz veins of both series. Numerous small fault planes are found to cut the cross veins, throwing them to the north,

Fig. 29.

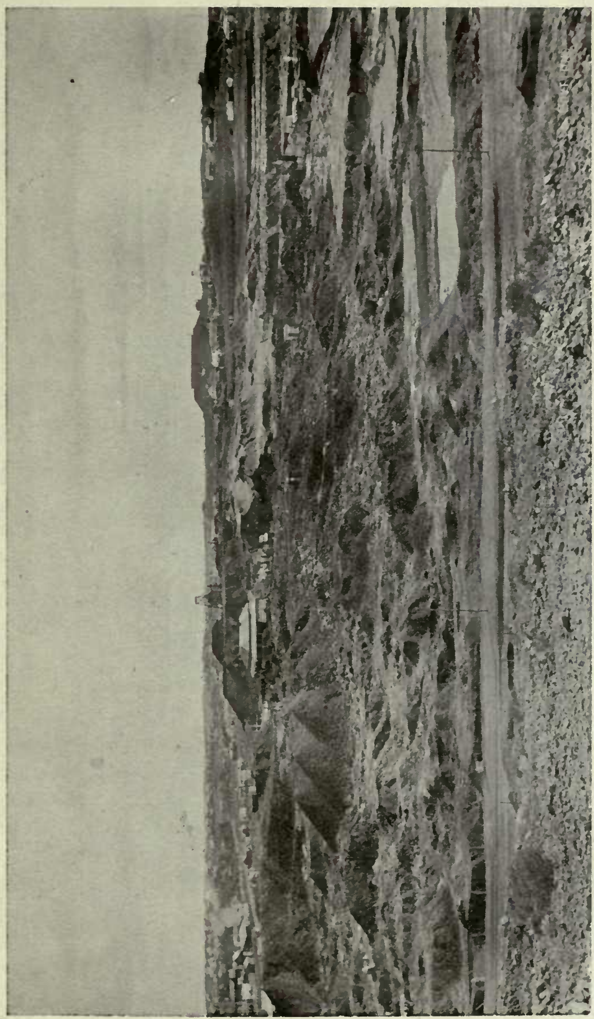


Photo: F. R. Feldtmann. Neg. F196.

From top of Mt. Gledden looking North, Cassidy Hill Main Shaft on top of first hill, Reward Shaft behind it, Cassidy N. Shaft and Plant on right, Mt. Charlotte in background.

going west, for distances varying from a few inches to about five feet (*vide* Plate VIII.), and the country in general is much jointed.

The main shaft, situated on the top of the hill, has a total depth of 180 feet from the surface, levels having been driven at depths of 63, 95, 118 and 180 feet.

Fig. 30.

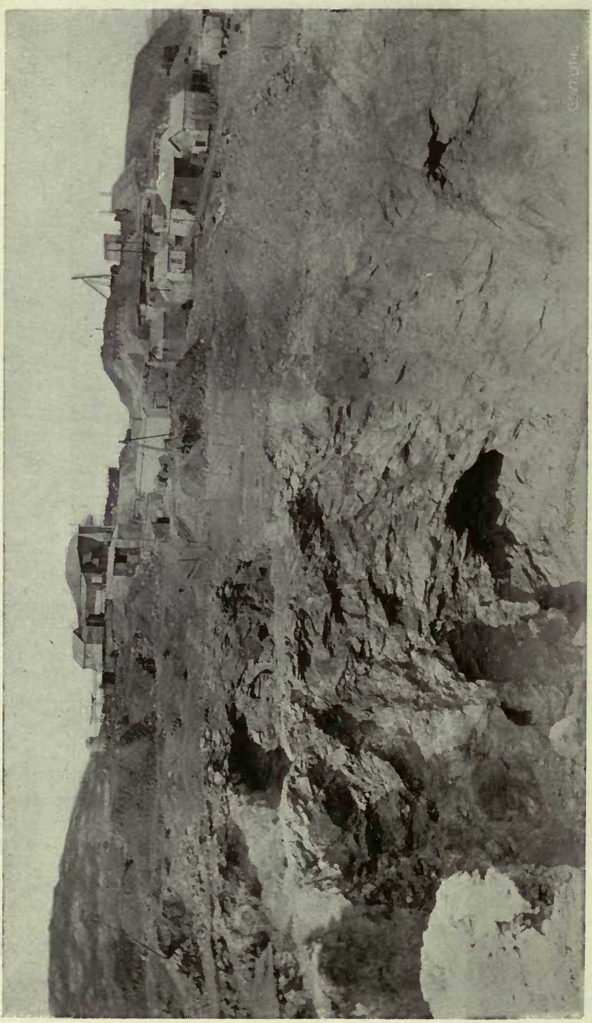


Photo: F. R. Feldtmann. Neg. F195.

Looking S., Southern Open Cut on G.M.L. 97E, Mt. Gledden in background, Cassidy Hill Main Shaft to right.

The steeper series of cross veins dips slightly to the south in this mine; a good deal of work has been done on these at the 63 and

118ft. levels. The flatter series have, however, been most persistently worked, particularly the No. 4 and No. 2 veins.

In one of the vertical veins close to the southern boundary in the 120ft. level from No. 1 shaft a small rich patch, showing much free gold, was associated with galena, hæmatite and a ferriferous carbonate. Some of the gold shown the writer from veins in the oxidised zone resembled that resulting from the decomposition of tellurides.

There is a small treatment plant on the mine.

Part of the returns for this lease are unfortunately combined with those from G.M.L. 392E outside this area, which was also one of the Paringa Mines, Ltd., leases.

The returns supplied are as follows:—

Name and Number of Lease.	Ore treated.	Gold therefrom.	Rate per ton.
	tons.	fine ozs.	fine ozs.
4E, Cassidy Hill	2,313·50	6,758·64*	2·92
4E, 392E, Paringa Mines, Ltd. ..	64,853·72	29,379·50	0·45
	67,167·22	36,138·14	0·54

* Includes 1,788·09 fine ozs. from specimens and dollied; 13·9ozs. of silver were also obtained.

CASSIDY'S NORTH G.M.L. 1163E. This lease, originally G.M.L. 3E, together with the adjoining G.M.Ls. 415E and 14CE, forms part of the Hannan's Consols leases, formerly the Hannan's Consols, Ltd. It adjoins the Hannan's Hill and Cassidy Hill leases.

The south-western half of the lease is in quartz-dolerite greenstone, the north-eastern half in the corresponding amphibolite. Much of the surface is hidden by a slimes dump. The southern portion of a small albite-porphyrite dyke runs through the northern corner; on the south-western side of this dyke is a small body of jasper. The northern portion of the albite-porphyrite dyke which runs to the south-west of Williamstown also runs through this lease, and can be seen at the 80ft. level from No. 3 shaft. There is another jasper formation about 14ft. wide on the south-western side of this dyke.

The two N.W.-S.E. striking shear zones which run into the Reward shear zone, run through this lease, the north drive at the 80ft. level from the main hauling shaft following the north-easterly one. The main shaft is situated 160 feet north of the south corner of the lease. North-west of the main shaft there are two large open cuts, with a third one crossing the boundary between this lease and

G.M.L. 97E. As usual, both cross veins and country from these cuts have been milled. Numerous shafts have been put down on the lease, on cross veins. No. 3 shaft has a depth of 290 feet, and at this depth a long crosscut connects with the Lady Elizabeth No. 1 shaft.

There is a small treatment plant on this lease.

Returns for this lease and G.M.Ls. 415E and 14CE are as follows:—

Name and Number of Lease.	Ore treated.	Gold therefrom.	Rate per ton.
	tons.	fine ozs.	fine ozs.
14CE, 415E, 1163E, Hannan's Consols Leases	52,012·67	10,228·06*	0·20

* Includes 2·84ozs. alluvial and 276·35 fine ozs. dollied and specimens.

LADY ELIZABETH G.M.L. 415E. This lease adjoins the last on the north-east. Roughly the western third of the lease is in quartz-dolerite amphibolite, the eastern two-thirds in dolerite-greenstone. The southern portion of a prominent jasper formation, best developed on a small hill to the north, runs into the lease and has been cut in the workings from the main shaft at depths of 96 and 296 feet. The main shaft is 306 feet deep. Some specimens of talc-chlorite-carbonate rock, probably occurring near the jasper, were found on the dump. The south-western end of another prominent jasper striking N.E.-S.W. crosses the north-eastern boundary. The previously mentioned albite-porphyrite dyke running south-west of Williamstown crosses through the southernmost portion of the lease.

Nothing of value appears to have been found on this lease, which has not been well prospected.

CALEDONIAN G.M.L. 14CE. This lease lies to the south of and adjoining G.M.Ls. 415E and 1163E. The south-western two-thirds are in quartz-dolerite greenstone, the remaining third in quartz-dolerite amphibolite, somewhat gabbroid in places, judging from Mr. Campbell's description. This portion of the lease is, however, hidden by the slimes dump. The westernmost of the two jaspers found in G.M.L. 1163E runs close to the north-eastern boundary of this lease.

There are several shallow shafts put down on cross veins in the greenstone in the southern portion of the lease.

MARITANA G.M.L. 279E. This lease adjoins the south-eastern boundary of G.M.L. 4E, and together with G.M.L. 2E (and formerly 3770E, now voided) forms one of the Maritana group of leases.

It is entirely in quartz-dolerite greenstone, but most of the surface is obscured by superficial deposits in which much dry-blowing has been done. The northern portion of the Maritana lode runs into this lease.

Several shallow shafts have been put down on cross veins in the lease, and a water shaft was put down to a depth of 258ft. on the road to Williamstown, near the south-western boundary of the lease; this shaft has been filled in.

Returns for the Maritana leases are given below:—

Name and Number of Lease.	Ore treated.	Gold therefrom.	Rate per ton.
	tons.	fine ozs.	fine ozs.
2E, 279E, Maritana G.M. Co., N.L.	11,373·50	4,660·82*	0·41
2E, 279E, 3770E, Maritana Leases	20,347·63	8,623·74*	0·42
3770E, Eaglehawk United ..	4,161·56	4,118·30*	0·99
Totals	**35,882·69**	**17,402·86***	**0·48**

* Includes alluvial, dollied, and specimens.

MARITANA G.M.L. 2E (Fig. 31). This adjoins the south-eastern boundary of G.M.L. 279E, and covers practically the whole of Mt. Gledden. It is entirely in quartz-dolerite greenstone. A lode formation striking N.W.-S.E. runs through the north-western portion of the lease; its south-eastern extension has not been followed. A fair amount of work has been done on the northern portion of this lode from the surface down to the 75ft. level from the main shaft, which is situated on the north-west slope of the hill, close to the corresponding boundary of the lease. Apparently this lode has not been cut in the lower levels of the mine, which are not sufficiently far to the west. A N.-S. shear zone, which was apparently taken for the lode, was cut in the west cross-cut at the 140ft. level (Fig. 32). This shear zone has faulted a cross quartz vein, and has also acted as a channel for vadose waters, the country on the western side at the 140ft. level being oxidised, that on the eastern unoxidised (Fig. 33).

A description has already been given of the lode formation, which has also been cut in an adit level in the south-western side of the hill.

There are numerous cross veins belonging to both series in the lease, and a good deal of work has been done on these from time to time.

EAGLEHAWK UNITED G.M.L. 3770E (voided). This lease adjoins the south-western boundary of the preceding lease and crosses the Brown Hill Railway line. The south-western two-thirds are in quartz-dolerite amphibolite, the north-eastern third in quartz-dolerite greenstone. The northerly extension of the barren lode from the former Hannan's Find, G.M.L. 4470E, runs into this lease at its southern end. Three shallow shafts have been sunk on this, apparently without finding payable values. The gold from this lease has evidently been largely obtained from cross quartz veins, or from superficial deposits.

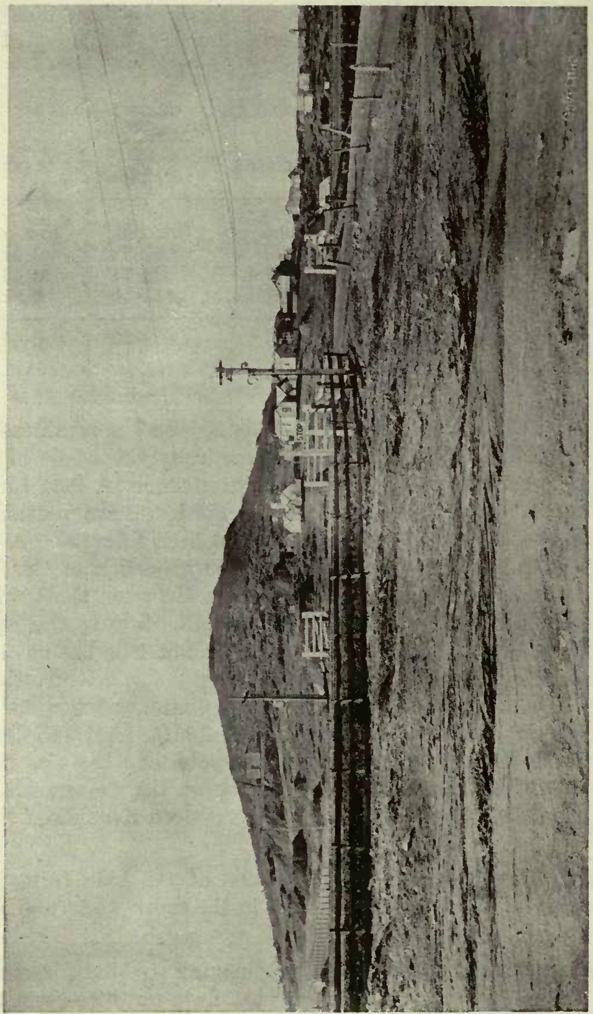


Fig. 31.

Photo: F. R. Feldmann. Neg. F197.

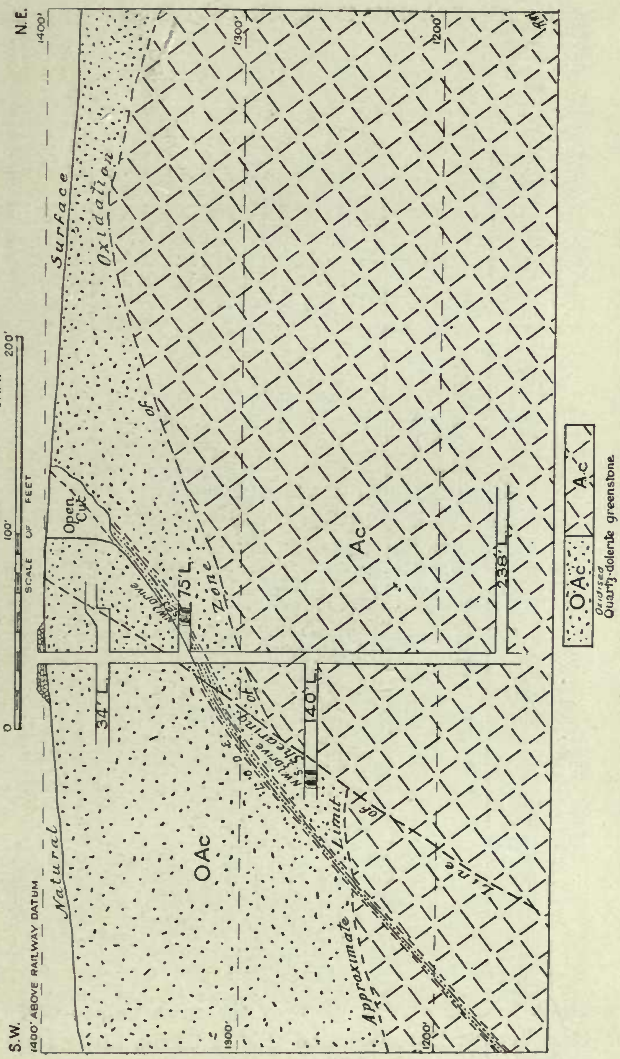
Mt. Gledden and Maritana Main Shaft (on left) from the West.

The lease has been fairly well prospected, particularly at the 73ft. level, connecting three shafts near the middle of the lease. From the dump of the central one of these, specimens evidently from a lower level, now inaccessible, were obtained of a very coarse pegmatitic variety of the quartz-dolerite amphibolites mentioned when dealing with those rocks. A cross vein, up to 14 inches in

Fig. 32.

MARITANA G. M. L. 37E.

CROSS SECTION THROUGH MAIN SHAFT

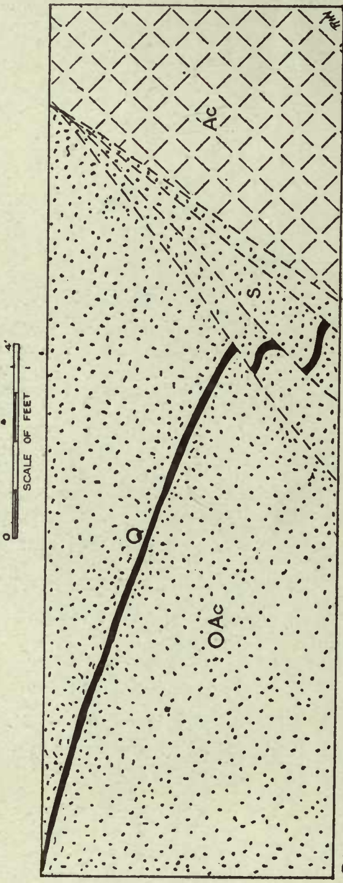


thickness, dipping south at a steep angle, had been followed near the northernmost of the three shafts; it appeared to contain a good deal of manganese oxide.

Lord Nelson G.M.L. 4477E (Figs. 34 and 35). This lease adjoins the south-eastern boundary of G.M.L. 2E; the ground was formerly part of G.M.L. 4303E, Sir John Forrest—the latter being previously held as G.M.L. 501E of the same name—G.M.L. 1591E, Sir John Forrest Extended, and G.M.L. 2988E, Little Duke, belonging to the Paringa Mines, Ltd.

Fig. 33.

MARITANA G.M.L. 37E



Cross section showing irregularity of zone of oxidation along a shear zone – S the latter faulting a cross quartz vein Q in quartz-dolerite greenstone Ac (oxidised · OAc).

The main belt of quartz-dolerite greenstone ends in this lease, the greater portion of which is in amphibolite. A N.-S. shear zone runs through the middle of the lease. There are numerous cross quartz veins of both series, on which a good deal of work has been done, particularly at the northern end of the ground.

Fig. 34.

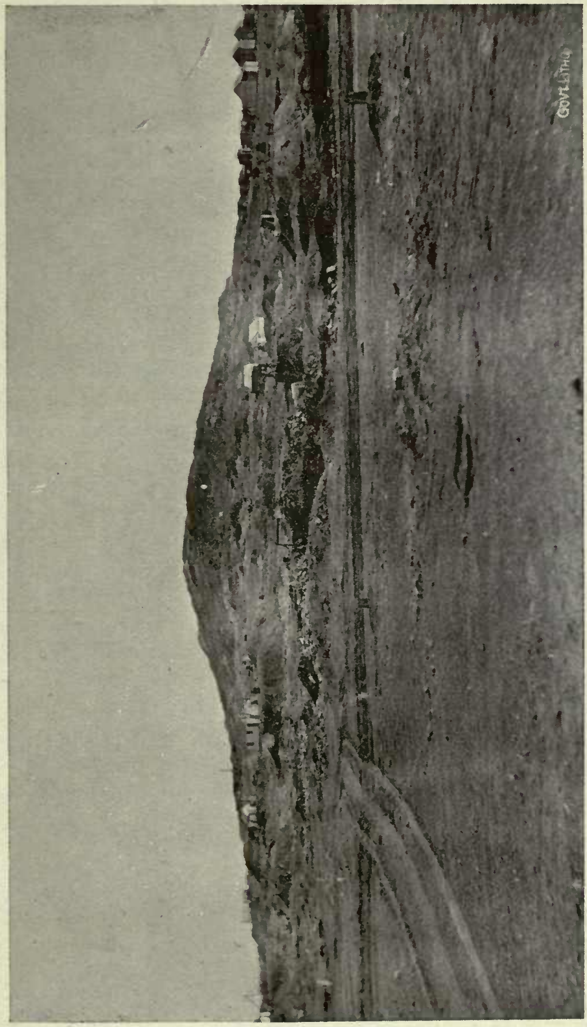


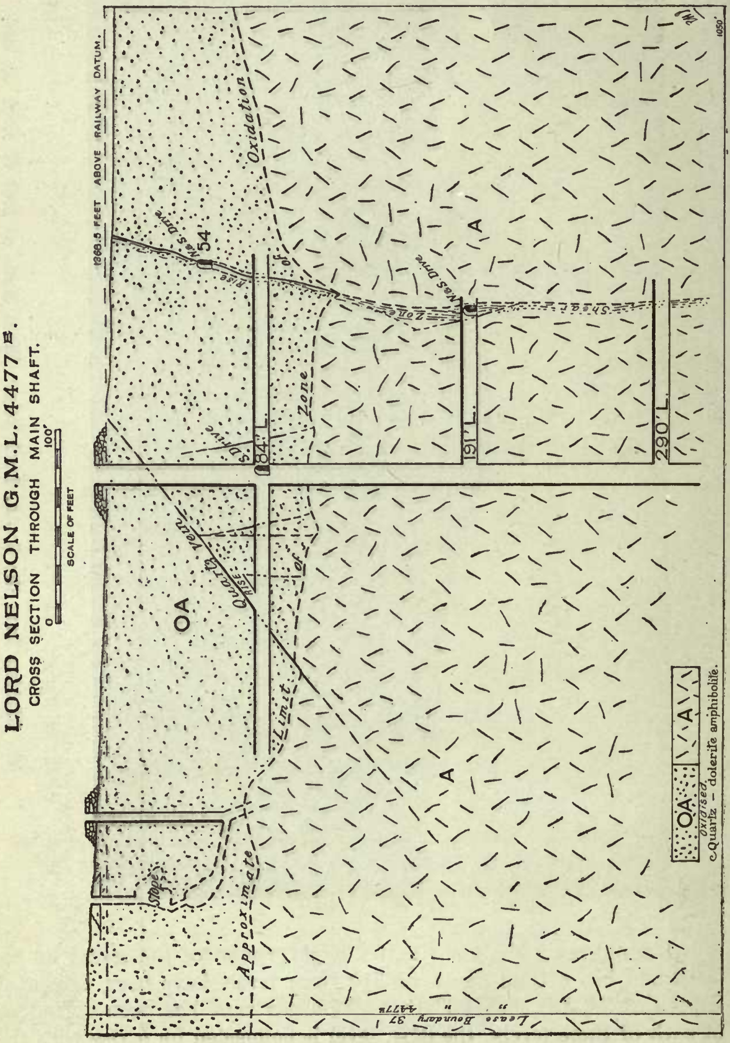
Photo: F. R. Feldmann. Neg. F198.

Mt. Gledden from the South, Lord Nelson Main Shaft at foot of slope on left.

The old main shaft is situated slightly west of the centre of the lease and has a total depth of 310 feet; levels have been driven at depths of 84, 191, and 290 feet; the shear zone has been driven on at each of these levels; the 84ft. level is connected by a rise with the

54ft. level from the No. 2 shaft, which is about 150 feet north-east of the main shaft. A little work has been done on cross veins at this level, and also at the 80ft. level. There are a number of other comparatively shallow shafts on the lease, and a good deal of dry-blowing has been done on the western half.

Fig. 35.



The only returns are for this lease and G.M.L. 4303E.

Name and Number of Lease.	Ore treated.	Gold therefrom.	Rate per ton.
	tons.	fine ozs.	fine ozs.
4477E, Lord Nelson	2,024·38	755·36*	0·37
4303E, Sir John Forrest	132·52	104·42*	0·79
Total	**2,156·90**	**859·78***	**0·40**

* Includes dollied and specimens.

HANNAN'S FIND G.M.L. 4470E (voided) and HANNAN'S FIND EX. G.M.L. 4471E (voided). These leases, which were held as the Hannan's Find leases, were situated between the Boulder and Brown Hill Railway lines, to the south-west of G.M.L. 4477E, which G.M.L. 4471E adjoined. The ground covered by G.M.L. 4470E was formerly part of G.M.L. 4056E of the same name, and, prior to that, part of the ground was held as G.M.L. 9E, Bohemian Girl, while the ground covered by G.M.L. 4471E was formerly part of G.M.L. 1511E, Lady Forrest.

The area occupied by these leases is entirely in quartz-dolerite amphibolite. A fairly long line of lode, splitting to the north, runs through G.M.L. 4470E and through former G.M.L. 42E (154) into the old Eaglehawk United. An unusual feature of this lode is the marked dip to the north-east. Although fairly well defined, this lode is practically barren, as might be expected from the nature of the country rock. A little work was done on it from the Lady Forrest and Bohemian Girl main shafts; the latter is situated on the top of a small laterite hill, under which a great deal of work has been done, the infralaterite being impregnated, in the usual fashion, with gold from cross quartz veins, of which there are a number on the ground, though perhaps not to the same extent as in the greenstone country. Most of the ground has been dry-blown.

Returns for these and former leases are as follows:—

Name and Number of Lease.	Ore treated.	Gold therefrom.	Rate per ton.
	tons.	fine ozs.	fine ozs.
4470E, Hannan's Find	140·00	27·38	0·19
4470E and 4471E, Hannan's Find Leases	1,132·00	196·45	0·17
4056E, Hannan's Find	1,506·00	291·74*	0·19
9E, 37E, 42E, Hannan's Find Gold Reefs, Ltd.	83·50	28·79	0·34
Totals	**2,861·50**	**544·36**	**0·19**

* Includes 6·06 fine ozs. alluvial.

Conundrum G.M.L. 4401E (voided). This lease was situated on the north-east side of the Brown Hill Railway line, and south-east of the Lord Nelson. It was formerly G.M.L. 4295E, Lady Wallace, and prior to that the northern part of the ground was held as G.M.L. 4150E, Found at Last, and the southern part as G.M.L. 4126E, Cardigan. At an earlier date the ground was covered by G.M.L. 1028E, Golden Point, held by the Hannan's Proprietary Development Co., Ltd.

The north-western half of the lease is in quartz-dolerite amphibolite, the south-eastern in fine-gained greenstone. A N.-S. shear zone, dipping to the west at about 55°, occupies the junction of the two rocks; near its northern end this joins a N.W.-S.E. striking formation, which occurs in the fine-grained greenstone. It is uncertain whether this latter formation belongs to the lode formations, or is merely another shear zone; in any case it does not appear to carry payable values.

There are several comparatively shallow shafts on the ground, some on cross quartz veins in the amphibolite. The veins in this lease are mostly small, and the unoxidised rock not being far from the surface in the southern portion of the amphibolite area, they are not always payable. From a shaft put down by the Hannan's Proprietary Co. in the southern portion of the lease, long crosscuts were put in to the north-east and south-west at the 75ft. level, the latter crosscut cutting the N.-S. shear zone, on which a little driving was done without payable results.

With the exception of a few cross quartz veins no payable formation is likely to be found on this lease.

Returns are as follows:—

Name and Number of Lease.	Ore treated.	Gold therefrom.	Rate per ton.
	tons.	fine ozs.	fine ozs.
4295E, Lady Wallace	114·00	6·41	0·06
4150E, Found at last	..	9·51*	..
4126E, Cardigan	47·00	9·67	0·21
Totals	**161·00**	**25·59**	**0·16**

* Dollied and specimens.

Devon Consols G.M.L. 4532E (voided) (Fig. 36). The ground covered by this lease was previously G.M.L. 3880E, and, prior to that, G.M.L. 3811E of the same name; it was first held as G.M.L. 1731E, Mt. Charlotte East. It lies to the south of the Union Club G.M.L. 4289E. The Transcontinental Railway line now runs through the ground, which is almost entirely in dolerite greenstone; the long line of jasper mentioned in the description of those rocks runs right through the lease, and on the east side of this, in that portion of the ground south of the Transcontinental Railway, is the northerly extension of the long line of fuchsite-carbonate-quartz rock which starts south of the Hidden Secret. In the Devon Consols

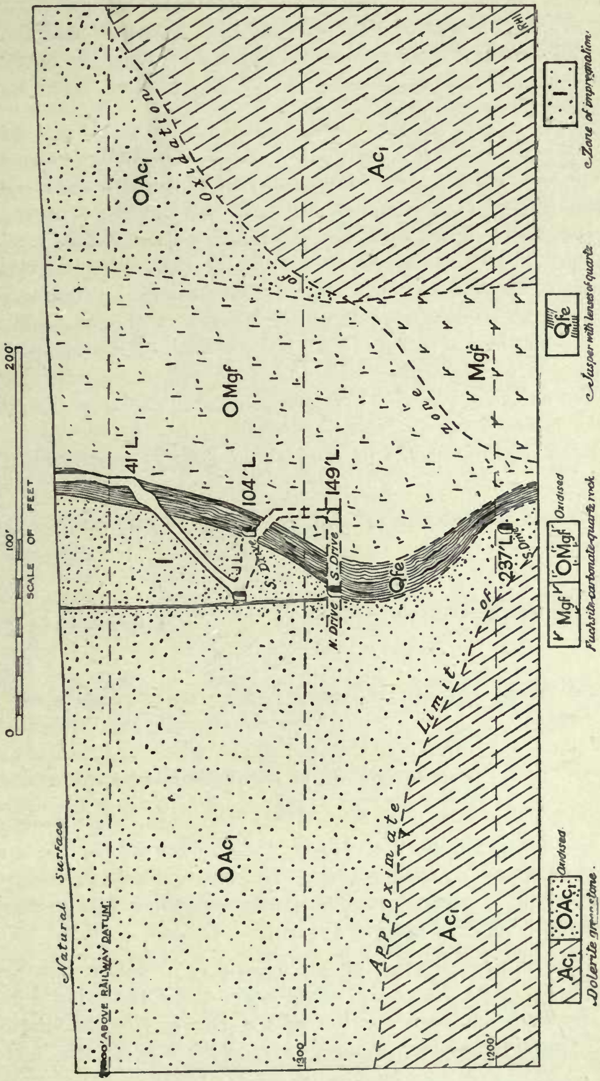


Fig. 36.

DEVON CONSOLS G.M.L. 173/E
CROSS SECTION THROUGH 41FT SHAFT.

this belt of fuchsite rock is ill-defined. A laterite-capped hill occupies the south-eastern corner of the lease.

There appears to be no defined lode formation on this lease, but the workings disclose a number of cross quartz veins, which cut into the jasper for a few feet. Some veins are very flat, and are bunchy and irregular near the jasper. There is said to have been a good deal of coarse gold at their junction with the latter, and they are probably responsible for the gold obtained from the oxidised country in its vicinity.

The main shaft is situated about 400 feet south-east of the north-west corner. I was unable to ascertain its total depth. The hanging wall of the jasper has been driven on for over 1,100 feet at the 149ft. level, and over 800 feet at the 237ft. level. A fair amount of work has also been done in the southern portion of the lease at the 100ft. level, which is connected by an incline rise with a shaft 41 feet in vertical depth, and rather more than 400 feet north of the south-west corner. At the 149ft. level the jasper is mainly composed of a varying width of pale yellowish-grey slaty laminæ, on the eastern side of which are a number of large irregular brown flinty quartz lenses. Near the southern end of the 237ft. drive the sulphide zone is met with and the jasper is replaced by graphitic schist.

The following are returns as supplied by the Mines Department Statist:—

Name and Number of Lease.	Ore treated.	Gold therefrom.	Rate per ton.
	tons.	fine ozs.	fine ozs.
3880E, 4146E, Devon Consols Leases	26,777·00	11,686·92*	0·44

* Includes 36·73 fine ozs. dollied and specimens.

Sons of Gwalia G.M.L. 3771E (voided). The ground covered by this lease adjoins the southern boundary of the Devon Consols. At one period it, together with G.M.Ls. 796E and 1228E, was held as one of the Bonnie Lass leases. At an earlier date it was taken up as G.M.L. 1623E, Reefer's Trident.

The western portion of the ground is in dolerite greenstone, the eastern in talc-chlorite-carbonate rock, while the middle is occupied by the southerly continuation of the Devon Consols line of jasper, with fuchsite-carbonate-quartz rock to the east of the latter.

There are a number of shafts on the ground, but only one—120 feet north from the middle of the southern boundary and about 20 feet west of the jasper—was accessible at the time of my visit;

this shaft has a total depth of 99 feet from the surface, and there were levels at depths of 28, 73, and 99 feet; in the north drive at the latter level was a winze in sheared oxidised rock to the west of the jasper; this winze reached a depth of 127 feet from the surface; from the bottom of this winze a small drive and crosscut led to the west wall of the jasper, on which was another winze, to a depth of 171 feet from the surface. The jasper was cut in the east crosscut at the 99ft. level, and was 33 feet wide here, the western 20 feet consisting of finely laminated grey slaty bands of cryptocrystalline quartz highly contorted in places (*vide* Fig. 7), the eastern 13 feet of coarse lenses of dark grey flinty quartz separated by bands of ferruginous crumbly and highly laminated matter. There are a number of steep northerly-dipping cross quartz veins on both sides of the jasper, usually pinching before actually reaching it. At the 73ft. level a crosscut connects with a shaft 170 feet west of the last, and continues for a further distance of 155 feet; an ill-defined formation striking about N.W.-S.E. and dipping S.W. at about 54 degrees was cut in this latter portion of the crosscut; it contains a few thin lenses of flinty quartz, but does not appear to have carried values.

A good deal of dryblowing has been done near the eastern corner of the lease.

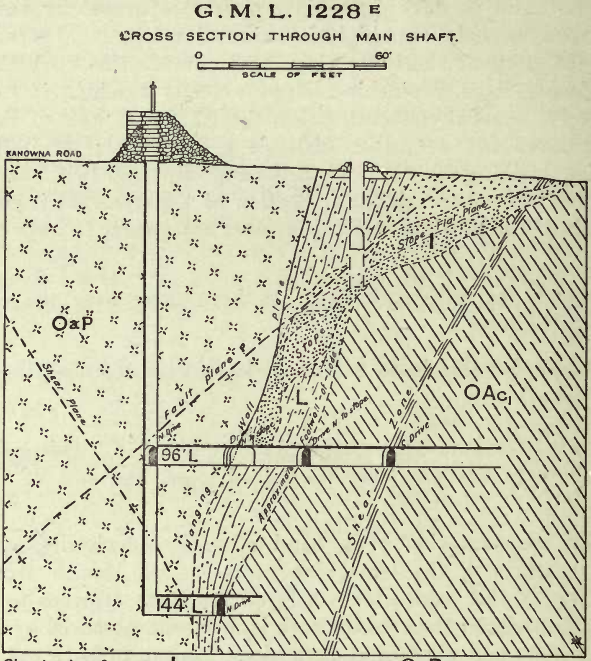
Returns for this lease are given later with those of the other Bonnie Lass leases.

RED WHITE AND BLUE G.M.L. 1228E (Fig. 37). This lease lies to the south of the previously described lease, and east of G.M.L. 213E.

With the exception of a band of albite-porphyrite, running diagonally through the lease—the south-eastern branch from the main dyke of that rock—the whole of the lease appears to be in dolerite greenstone; the country rock is, however, obscured by superficial deposits, and none of the workings appear to have got below the limits of the oxidised zone.

A lode formation occurs on the eastern wall of the albite-porphyrite, apparently the southerly continuation of the Mystery line of lode. The hanging wall of this lode is fairly well defined and, so far as can be judged in the oxidised zone, is on the junction of the two rocks. Another shear zone, striking more north-westerly and cut in the east crosscut at the 96ft. level, runs to join the lode on the eastern side of the latter, and may have had some influence on the distribution of values, as a small but very rich shoot of ore was found near the junction of the two. In the stope near the surface (*vide* Fig. 37) is a thin flat vein of ironstone, evidently marking another line of shearing; this also runs into the hanging-wall plane, and the country in its vicinity has been impregnated to some extent. The rich shoot carried some beautiful specimens of sponge gold, and I was informed by Mr. C. de J. Grut, attorney for the Hannan's Reward, Ltd., that the oxidised ore, which he had personally tested, showed a strong reaction for tellurium. This is in favour of the permanency of the formation, and further prospecting will in all probability reveal other shoots of ore.

Fig. 37



Showing lode formation - L at junction of albite-porphyrite OaP *(oxidised)* and dolerite-greenstone OAc₁ *(oxidised)*. Ore shoot 1.

The main shaft from which the ore-body is worked is situated on the eastern side of the Kanowna Road, and is 144 feet in depth. A good deal of work has been done at the 96ft. level, and there is a short crosscut and a north drive on the lode at the 144ft. level. There are numerous other shafts on the lease, but none were accessible at the time of my visit.

A number of cross quartz veins west of the main jasper have been worked near the eastern boundary of the lease. Most of the surface has been dryblown.

Bonnie Lass G.M.L. 796E.

This lease lies to the southwest of and adjoining G.M.L. 1228E, and also adjoins the eastern boundaries of G.M.Ls. 4529E and 211E.

In the northern portion of the lease, none of the workings appear to have gone below the limit of oxidation and the exact nature of the country rock is doubtful, but it is most probably quartz-dolerite greenstone. A band of talc-mesitite rock occupies part of the south-western portion, being exposed on the dump of an inaccessible shaft 280 feet north-east of the south corner of the lease and said to be 249 feet in depth. To the south-west of the talc-mesitite rock is the continuation of the band of fuchsite-carbonate-quartz rock met with in the eastern workings from the "Charlotte" main shaft. In this fuchsite rock is a dyke of albite-porphyrite and a wide band of graphitic schist; these are exposed in the workings from a shaft near the western boundary and 170 feet north of the south corner. The prominent laterite-capped hill mentioned in the description of G.M.L. 4529E extends across the northern end of this lease. Four shafts have been sunk through it, one, now inaccessible, to a depth of 162 feet, another, which I was able to examine, to a depth of 107 feet. From the last-mentioned shaft levels have been driven at depths of 28, 48, 69 and 107 feet; a great number of cross quartz veins usually dipping steeply to the north, and only a few feet apart, have been worked from these levels (*vide* Fig. 18). In many instances they seemed to be vein systems rather than simple veins. On the walls of some of these veins was a little green, probably chromiferous puggy material, and a thin fuchsitic seam was observed at the southern end of the south drive at the 69ft. level. At the 107ft. level, a long croscut east connects with the west crosscut from a shaft 112 feet deep just inside G.M.L. 1228E. At the junction of the two crosscuts is a winze to a depth of 184 feet from the surface. About 40 feet from the shaft on G.M.L. 1228E the country changes and becomes paler and numerous "soapy heads" are present. Owing to the decomposed state of this rock it is impossible to determine its origin. It may have been either highly sheared and altered greenstone, or albite-porphyrite.

From the previously mentioned shaft on the jasper near the south corner of the lease, levels have been put in at depths of 35 and 203 feet. The east crosscut at the former level cuts the albite-porphyrite dyke; towards the eastern end of the crosscut this dyke is more sheared and contains numerous greenish inclusions. The jasper is best seen at the 203ft. level, where it consists mainly of grey slaty laminæ, but ferruginous in places; it appears to be more graphitic near the western wall. A winze from this level reaches a total depth of 263 feet from the surface—this was inaccessible.

There is a 10-head battery and a cyanide plant on this lease.

Returns for the Bonnie Lass leases are as follows:—

Name and Number of Lease.	Ore treated.	Gold therefrom.	Rate per ton.
	tons.	fine ozs.	fine ozs.
796E, 1228E, Bonnie Lass Leases	6,011·00	6,105·91*	1·01
796E, 1228E, 3771E, Bonnie Lass Leases	11,307·65	6,461·52	0·57
796E, 1228E, Hannan's Reward N. G.M. Co., N.L.	334·00	264·21*	0·79
1228E, Red White and Blue ..	130·00	25·56	0·20
3771E, Sons of Gwalia	1,428·00	844·54	0·59
Totals	**19,210·65**	**13,701·74***	**0·71**

* Includes Dollied and specimens.

HANNAN'S REWARD NORTH G.M.L. 4528E.

This lease adjoins the southern boundary of G.M.L. 1228E and the eastern boundary of G.M.L. 796E, and like them, is held by Mr. Raven. The ground was formerly part of G.M.Ls. 4440E Battler, and 4057E Criterion; G.M.L. 4440E was formerly held as G.M.L. 4115E Sarnian, and prior to that formed part of G.M.L. 3964E Belgravia, and at an earlier date G.M.L. 2688E Hannan's Hill Extended. G.M.L. 4528E also includes a small portion of former G.M.L. 4438E Battler East, formerly G.M.Ls. 4385E A.I., 4113E Hidden Fortune, and 4043E Orkedon.

The continuation of the albite-porphyrite branch which runs through the Red White and Blue appears to run through this lease, the rest of which is in dolerite-greenstone. Crossing the southern boundary is the northerly extension of the prominent jasper body which runs through the Lady Elizabeth.

There were only three shafts on the ground at the time of my visit, all being inaccessible. On the dump of one near the eastern boundary, graphitic schist was much in evidence; the workings from this shaft—said to be 150ft. deep—were inaccessible, but a crosscut is said to have been put in to the north-west, in which values were obtained. As the Red White and Blue albite-porphyrite dyke apparently runs through this lease, it is probable that the lode on the eastern side of the dyke also runs into this ground, and the values from the above-mentioned crosscut may be from the vicinity of this lode which should be worth prospecting. A crosscut west from this shaft would probably cut the lode at roughly 140 feet west of the shaft.

There are no returns for this ground, but those for former leases covering the voided area to the south-east are given below:—

Name and Number of Lease.	Ore treated.	Gold therefrom.	Rate per ton.
	tons.	fine ozs.	fine ozs.
4438E, Battler East	44·00	3·70	0·09
4113E, Hidden Fortune	10·00	3·80	0·38
Totals	**54·00**	**7·50**	**0·14**

HIDDEN SECRET NORTH G.M.L. 4035E.

This is the northernmost of the Hidden Secret leases; it lies to the south of the former Battler East, and to the east of the Lady Elizabeth, but is separated from the latter by a narrow strip of vacant ground. The ground was formerly the southern portion of G.M.L. 254E Holdings' lease.

The western portion of the lease is in dolerite-greenstone, the eastern in actinolite-zoisite amphibolite, but in places in the area occupied by the former, intermediate stages between the two rocks are found; for instance, on the dump of a shaft half way along the south-western boundary. A number of thick N.E.-S.W. striking jasper lenses are a prominent feature in the north-western portion of the lease.

Besides the shaft on the south-western boundary, there are three other shafts on the ground; the northern two are connected by a long crosscut at the 75ft. level (in oxidised rock) the greater portion of this crosscut runs through the above-mentioned jasper, which is somewhat contorted and shows numerous small fault and joint planes; south-east of the jasper the country is jointed, and shows bleaching in places. From the northernmost shaft, which is 140 feet deep, drives run north and south at the 75ft. level on a somewhat ill-defined formation with some lenses of flinty quartz; this formation is apparently on much the same line as the main Hidden Secret lode, but it is evidently unpayable.

Much of the surface has been dryblown.

HIDDEN SECRET G.M.L. 4001E (Fig. 38). This lease adjoins the south-eastern boundary of the Hidden Secret North, and was formerly part of G.M.L. 1034E, Hidden Treasure South, of the Hannan's Proprietary Development Co., Ltd.

The western and larger part of the lease is in dolerite greenstone, the eastern in talc-chlorite-carbonate rock. A band of fuchsite-carbonite-quartz rock, with a westerly dip of about 59 degrees, runs through the eastern portion of the lease at the surface; at the 198ft. level, where it has been driven on for some distance, it is about in the middle of the lease, and it cuts across the main shaft at a depth of 360 feet from the surface to join the main lode, which dips more steeply, just about the 404ft. level (*vide* Fig. 15).

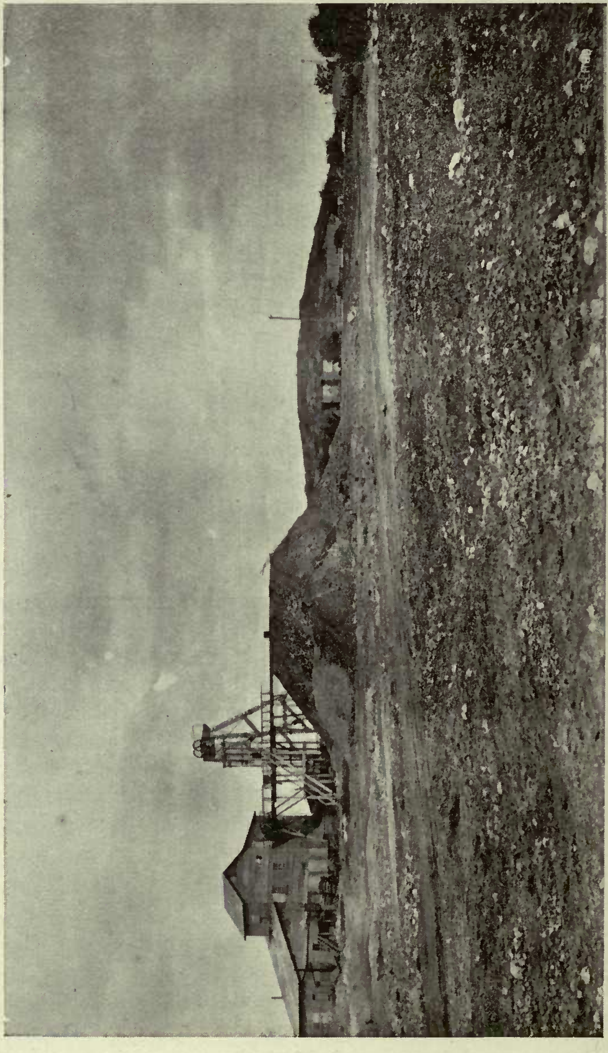


Fig. 38.

Hidden Secret Main Shaft from North.

Photo: F. R. Feldtmann.

Neg. F199.

The main shaft is situated about 290 feet north of the southern corner of the lease; it is 430 feet in depth, and levels have been put in at depths of 89, 198, 304, and 404 feet, while there are several intermediate levels on the lode in different parts of the mine, connected by winzes or rises with the main levels.

The main lode runs through the middle of the lease at the surface; north of the main shaft it splits into two branches which diverge at an angle of, roughly, 16 degrees; the junction between them appears to be nearly vertical, but pitches to the south between the surface and the 89ft. level. The rich shoot or "pipe" of telluride ore appears to have been closely connected with the junction of the two branches. This shoot has now been stoped out, and it is almost impossible to form any idea as to the shear lines which controlled the ore deposition, but it certainly occurred very close to, if not actually at, the junction of these branches. Its approximate position is shown on the longitudinal section (Plate VII.). The shoot was said to start at about 35 feet from the surface, lengthening out suddenly above the 89ft. level to about 15 feet between the 89ft. and 198ft. levels, the pitch was nearly vertical, and the length apparently fairly constant; at between 30 and 40 feet below that level it lengthened to between 30 and 40 feet, according to Mr. Gianini, shortening again suddenly and apparently pinching just above the 304ft. level; good values were obtained at that level below the shoot and in the winze between the 304ft. and 404ft. levels, and in the winze to 436 feet, near the southern end of the drive at 404 feet, good values were also obtained. At the time of my visit work was being carried on at the southern end of the drive at 404 feet.

The general structure and mineral composition of the lode were described in that portion of the report dealing with the ore deposits, and nothing further need be said here.

Other fairly rich shoots of ore have been worked in the upper levels, principally above the 89ft. level and on the eastern branch of the lode north of the main shaft, as may be seen on the longitudinal section; these appear to be of the usual roughly lenticular shape characteristic of the Kalgoorlie lodes.

Although rich shoots of telluride ore such as that of this mine occur under special conditions—depending largely upon the junction of two or more shear planes—and it cannot be expected that others equally rich will be found except under similar conditions, there seems to be no reason why other shoots of payable ore should not be found on this mine by further prospecting; in the search for these, the shear planes that have acted as "indicators" for the previously worked shoot should be carefully watched.

The plant consists of a 5-head stamp battery and one No. 4 Krupp ball mill, together with one Wilfley table and four cyaniding vats.

Hidden Secret South G.M.L. 4036e. This lease adjoins the south-eastern boundary of G.M.L. 4001e, and, like it, was formerly held as part of the Hidden Treasure South G.M.L. 1034e. As with the preceding lease, the western half of the ground is in dolerite greenstone, the eastern half in talc-chlorite-carbonate rock. The band of fuchsite rock appears to run through the middle of the lease, but is nowhere exposed, and its exact position is uncertain.

The main line of lode worked on this lease appears to run, roughly, from 40 to 70 feet to the west of that of the previously described lease, unless it should prove to be the same lode faulted to the west going south; the two, however, probably represent two distinct lines of shearing along a main zone. The main line of this lease is also found to split, in this case at its southern end.

The main shaft on this lease (B shaft) is situated about 240 feet west of north from the southern corner, and is 153 feet in depth, levels being driven at depths of 53, 99, and 153 feet, all in oxidised rock, with the exception of the extreme north end of the drive at the last level; sulphides were met in two winzes below this level. The general shape of the ore-shoot may be gathered from the longitudinal section (Plate VII.). The workings being practically all in oxidised rock, no description of the lode below the limit of oxidation can be given, but it probably closely resembles that of G.M.L. 4001e.

A good deal of work was done by the owners of the Hidden Secret leases further south on the same line of lode, from the "Federal" shaft now within G.M.L. 4501e, Secret Extended, and prior to that G.M.L. 4107e, Hidden Secret West, and G.M.L. 1099e, Central; Thornett Bros. also worked a shoot on this lode to the north of the Federal shaft, from a shaft near the western corner of G.M.L. 4051e, A.W.A. United. All these workings are shown on the longitudinal section. At the 155ft. level from the Federal shaft the unoxidised rock has been penetrated, the country in the vicinity of the lode is highly sheared and carbonated, and there are some large irregular lenses of quartz in the lode.

As no other work has been done on G.M.L. 4501e other than that from the Federal shaft, no special description of it need be given—it is entirely in dolerite greenstone and covers a large portion of the townsite of Williamstown on which practically no prospecting has been done, and within which it is by no means improbable that payable lodes may yet be found.

Returns for the Hidden Secret leases are given below, also those for the Hidden Secret West.

Name and Number of Lease.	Ore treated.	Gold therefrom.	Rate per ton.
	tons.	fine ozs.	fine ozs.
4035E, 4001E, 4036E, Hidden Secret Leases	10,643·95	15,384·83*	1·45
4107E, Hidden Secret West ..	561·00	68·04	·12
Totals	11,204·95	15,452·87	1·38

* Includes 105·65 fine ozs. dollied and specimens, and in addition 43,383·29 fine ozs. of silver were extracted.

GREAT SECRET G.M.L. 4450E (voided). This lease was situated to the south-east of and adjoining the Secret Extended. The ground was previously held as two leases, the northern being G.M.L. 4124E, Great Secret, and the southern G.M.L. 4281E, Mt. Ferrum West—the latter being included in the A.W.A. United leases. Prior to that the southern portion was G.M.L. 1111E, Phœnix, which, together with G.M.L. 1101E, was held by the Brown Hill Junction G.M. Co., N.L. The northern portion of the ground is in quartz-dolerite greenstone, the southern in fine-grained greenstone.

The southern end of the long line of formation which follows the junction of the Older and Younger Greenstones so closely runs through this ground; it has been cut in a small shaft 56 feet in depth and about 360 feet west of the east corner. In this shaft this formation in places presents the appearance of a spotted tourmaline-quartz-breccia mentioned in the description of the formation in that part of the report dealing with the Ore-deposits. Near the eastern corner of the lease is another line of formation, striking N.W.-S.E. and running towards the first-mentioned formation, which it should meet at approximately 210 feet N.N.W. of the south corner of the former A.W.A. lease; as fair patches have been obtained from similar junctions along the thin contact formation, this point is worth prospecting. Some work was being done by Messrs. Barrass and Hamilton on the N.W.-S.E.-striking lode from a 40ft. shaft about 110 feet east of the east corner of the ground, but values were said to be generally poor. 200 feet west of the same corner a shaft 103 feet in depth cut an E.-W.-striking formation dipping to the north at varying angles, but usually fairly shallow; this may be a fault line or a cross formation joining the two lode formations; it does not appear to fault the N.W.-S.E. lode so far as could be seen.

Returns for G.M.Ls. 4281E and 1111E are included in those for the A.W.A. United and Brown Hill Junction leases; those for G.M.L. 4124E are given below:—

Name and Number of Lease.	Ore treated.	Gold therefrom.	Rate per ton.
	tons.	fine ozs.	fine ozs.
4124E, Great Secret	291·00	281·19*	0·97

* Includes 201·53 fine ozs. dollied and specimens.

MT. FERRUM WEST EXTENDED G.M.L. 4371E (voided).

This lease adjoined the south-western boundary of the preceding lease. It was formerly G.M.L. 4114E, Secret South, and prior to that portion of G.M.L. 1026E, Kalgurli, of the Hannans Proprietary Co.

With the exception of the westernmost portion, in quartz-dolerite amphibolite, the whole of the ground is fine-grained greenstone. The southern end of the Williamstown albite-porphyrite dyke crosses the north-west boundary of the lease with a jasperoid formation on its eastern wall.

There were only four shafts on the ground, all inaccessible; on the dump of the northernmost was a fairly coarse-grained highly-sheared rock, now a chloritic schist, with paler spots, now made up of an obscure mosaic; the rock is probably an exceptionally coarse variety of the fine-grained greenstones.

On the dump of the easternmost shaft were fragments of a white cellular rock showing a number of fine, black tourmaline needles; a little sericite was also present. This may represent a formation similar to the N.-S. line on G.M.L. 4450E.

There are no returns for this ground.

BROWNHILL CONSOLS No. 2 G.M.L. 4356E (voided).

The ground covered by this lease adjoins the south-eastern boundary of the preceding lease. It was formerly held as G.M.L. 4119E, Montezuma, and prior to that was also part of G.M.L. 1026E.

It is entirely in fine-grained greenstone, but Mr. Campbell's map shows a narrow dyke of "felsite"—probably albite-porphyrite—as occurring in the east cross-cut from a shaft (No. 1), 350 feet south of the north corner. Cross-cuts have also been put in from the No. 2 shaft near the south-west boundary. None of these workings were accessible.

Apparently no values were obtained in the crosscuts, and there are no returns for the ground.

WILLIAMSTOWN G.M.L. 4499E (Fig. 39).

This lease lies to the south-east of former G.M.L. 4450E, and to the north-east of the previously described lease, and, like it, is

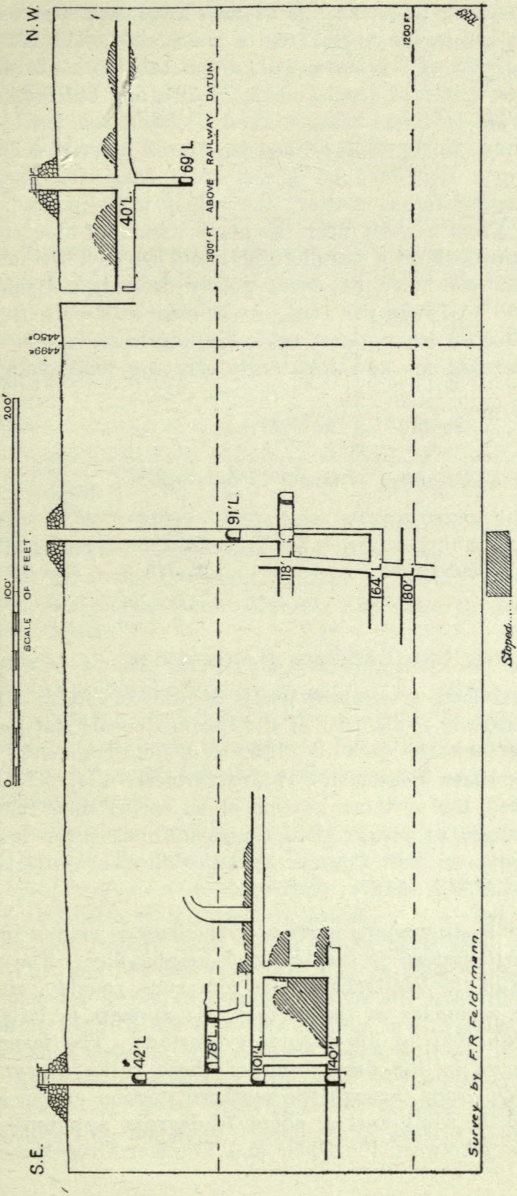


Fig. 39.

WILLIAMSTOWN G.M.L. 4499E

LONGITUDINAL SECTION.

entirely in fine-grained greenstones. The ground was formerly held as G.M.L. 4302E, Mannajone, and at an earlier date as G.M.L. 860E, Brown Hill Consols North.

At the time of my visit the holders, Messrs. Sassella Bros., were working the same line of lode as Messrs. Barrass and Hamilton further to the north from a shaft about 415 feet south of the north corner of the lease, with a vertical depth of 145 feet; levels had been driven at depths of 42, 78, 101, and 140 feet, all in oxidised rock. The lode was being worked at the bottom level; it was a narrow body, fairly well defined in places, poorly defined in others, carrying a few irregular lenses of quartz, with some ferruginous and manganiferous matter; the values were patchy, but generally poor. From a shaft near the north corner of the lease some work had been done on a parallel line about 60 feet further west, and of a similar character, but more poorly defined, and said to be worth from *nil* to 7dwts per ton. Associated with both formations were a number of cross quartz veins dipping to the north at from about 45 to 60 degrees, and apparently carrying some manganese.

Returns are as follows:—

Name and Number of Lease.	Ore treated.	Gold therefrom.	Rate per ton.
	tons.	fine ozs.	fine ozs.
4499E, Williamstown	1,321·23	370·08	0·28

NORTH END EXTENDED G.M.L. 4485E.

This lease is situated south of and adjoining the Kanowna Road, slightly to the east of the Devon Consols and Sons of Gwalia. It was formerly part of G.M.Ls. 4046E, Hannan's Hope, 4369E, Colleen Bawn South, and 4157E (formerly 4047E), Hannan's Hope Extended, the northern portion at an earlier date forming parts of G.M.Ls. 3805E, Brown Hill Consols No. 2, prior to that G.M.L. 1268E, Brown Hill Consols North, while the southern portion was part of G.M.L. 1187E, Outridge.

The south-western portion of the lease is mainly in hornblendite, the north-eastern in fine-grained amphibolite. The northerly extension of the Westralia United lode runs, roughly, along the north-eastern boundary at the surface. It appears to be surrounded by a narrow strip of fine-grained greenstone. The jasper—previously mentioned in the description of those rocks as running towards this lode—runs through the southern portion of the lease, where it dips to the south-west at about 74 degrees, apparently marking the boundary between the Older and Younger Greenstones.

Some work has been done on the lode from a shaft, 77 feet deep, near the eastern corner of the lease, the lode having been driven on at the 48 and 77ft. levels, and stoped to some extent between them and the surface.

There are several other shafts on the lease, the workings of which were inaccessible; much of the surface has been dry-blown, particularly along a well-defined watercourse running across the southern portion of the lease. As the lode in the Westralia United has yielded very good shoots from time to time, its northerly extension will, doubtless, bear further prospecting.

Returns are as follows:—

Name and Number of Lease.	Ore treated.	Gold therefrom.	Rate per ton.
	tons.	fine ozs.	fine ozs.
4485E, North End Extended ..	281·14	86·30	0·31
4046E, Hannan's Hope	15·00	1·24	0·08
4157E, Hannan's Hope Extended ..	..	2·62*	..
Totals	**296·14**	**90·16**	**0·30**

* Dollied and Specimens.

LUCKNOW G.M.L. 4464E. This lease adjoins the eastern boundary of G.M.L. 1228E, Red White and Blue, and was formerly G.M.L. 4006E, Hannans Oversight, and at an earlier date part of G.M.L. 3776E, Kalgoorlie Mount Morgan, and prior to that part of G.M.L. 1094E, Austral.

The lease is almost entirely in talc-chlorite rock, while the main line of jasper running south from G.M.L. 3771E runs along the eastern boundary; east of this is the main belt of fuchsite rock. Another smaller jasper runs through the latter in the southern portion of the lease. A small hill at the southern end of the ground is capped by dense laterite.

A long watercourse runs from G.M.L. 1228E through this lease and thence through the Westralia United leases; a good deal of dryblowing has been done in its vicinity. Near the northern end of the lease and close to the western boundary is a shaft 144 feet in depth, on the jasper, from which levels have been put in at depths of 51, 99, and 144 feet (*vide* Fig. 6). In these workings there are several smaller lenses of jasper close to and west of the main line; the latter dips to the east—its laminæ are a good deal contorted; the usual series of coarse flinty lenses is found on its eastern side. Sulphide rock is met with only at the end of the west crosscut at the 144ft. level; here the rock is hard, pale grey in colour, and highly carbonated; it appears to contain a little fuchsite.

On the top of the hill, in the laterite, is another shaft, said to be 200 feet deep, at which depth crosscuts run east and west; from the former is a winze to a total depth of 312 feet from the surface; the east crosscut is in jasper between the shaft and the winze. The dump of this shaft is mainly composed of highly graphitic schist. 200 feet north-east of this last shaft is another, said to be 100 feet in depth; it is in fairly typical talc-chlorite-carbonate rock. There are several shallow shafts on the ground in the vicinity of the laterite, but the northern portion of the ground does not appear to have been very well prospected.

Returns for the Lucknow are as follows:—

Name and Number of Lease.	Ore treated.	Gold therefrom.	Rate per ton.
	tons.	fine ozs.	fine ozs.
4464E, Lucknow	31·00	3·91	0·13

North End Deeps, 4507E. This lease lies to the east of and adjoining the Lucknow. It was formerly G.M.L. 4312E Ellendale, and prior to that G.M.L. 4169E of the same name. With the Lucknow it also formed part of G.M.Ls. 3776E and 1094E.

The lease is almost entirely in hornblendite, the extreme eastern portion being in quartz-dolerite amphibolite.

There are only three shafts on the ground—all inaccessible.

Most of the ground at the northern end has been dryblown.

From the amphibolitic nature of the country rock, the occurrence of payable ore-bodies on this lease can hardly be expected.

There are no returns for this ground.

Bonnie Play G.M.L. 4088E. This lease adjoins the south-eastern boundaries of the Lucknow and the North End Deeps, and is mainly situated between the Parkestown and Bulong roads, close to their junction. The lease was formerly part of G.M.L. 1030E Hidden Treasure Extended.

A broad band of dolerite greenstone runs through the middle of the lease, west of that is talc-chlorite-carbonate rock, while a comparatively narrow band of hornblendite is found near the eastern corner; this latter rock apparently ends close to the north-east boundary; a narrow tongue of actinolite-zoisite amphibolite enters the lease from the south and runs north as far as the Bulong Road, while the western corner of the ground is in fuchsite-carbonate quartz rock.

There are apparently no lode-formations within this lease, but a number of cross veins of vitreous, somewhat oily-looking quartz, dipping to the north at about 80 degrees, have been worked at the 56ft. level from two shafts near the north-eastern boundary.

Near the western corner of the lease is a shaft 57 feet deep, near the eastern boundary of the fuchsite rock. At the 22ft. level from this shaft there are a number of quartz veins striking in various directions and with a fair amount of fuchsite round them. There are several other shafts on the ground, but nothing of value appears to have been struck in them, and apparently the only workable ore-bodies in the lease are the cross quartz veins in the band of dolerite greenstone.

A watercourse runs east through the middle of the lease, and a good deal of dry-blowing has been done in its vicinity.

Available statistics show a total of 83.61 tons treated for a return of 12.14 fine ounces—an average of 0.15 fine ounces per ton.

DAR KAN G.M.L. 4368E. This is a small triangular lease adjoining the south-eastern boundary of the North End Extended and the northern boundary of the North End Deeps, and is one of the Westralia United Goldfields, Ltd., leases. It was formerly part of G.M.L. 1187E Outridge.

The greater portion of the lease is in hornblendite, the northernmost portion being probably in quartz-dolerite amphibolite and fine-grained greenstone. The Westralia United lode runs across the lease close to the north corner.

There are three shafts on the ground, two in the vicinity of the lode.

Most of the surface has been dry-blown.

DEVON CONSOLS SOUTH EXTENDED G.M.L. 4037E (Figs. 40 and 41 and Plate VI). This lease, which adjoins the south-eastern boundary of the Dar Kan and the north-eastern boundary of the North End Deeps, is the most important of the Westralia United Goldfields, Ltd., leases. It was formerly part of G.M.Ls. 1187E Outridge, 2679E Hannan's Hope, 1094E Austral, and 1136E Euclid.

The south-western two-thirds of the lease are in quartz-dolerite amphibolite—or the corresponding greenstone, in the vicinity of the lode—the remaining third in fine-grained greenstone. In the southern portion of the lease the lode appears to follow the junction of the Older and Younger Greenstones, turning into the former in the northern portion of the ground.

The main shaft is situated near the middle of the lease, west of the outcrop of the lode, which it cuts at a depth of 190 feet. Levels have been driven at depths of 70, 160, 231, and 329 feet, the shaft itself being 335 feet in depth; north of the main shaft are several intermediate levels. As may be seen on the longitudinal section (Plate VI.), a great deal of stoping has been done, particularly in the upper levels, where several very good shoots have been found; the general shape of these may be gauged from the section; values appear to have been generally erratic.

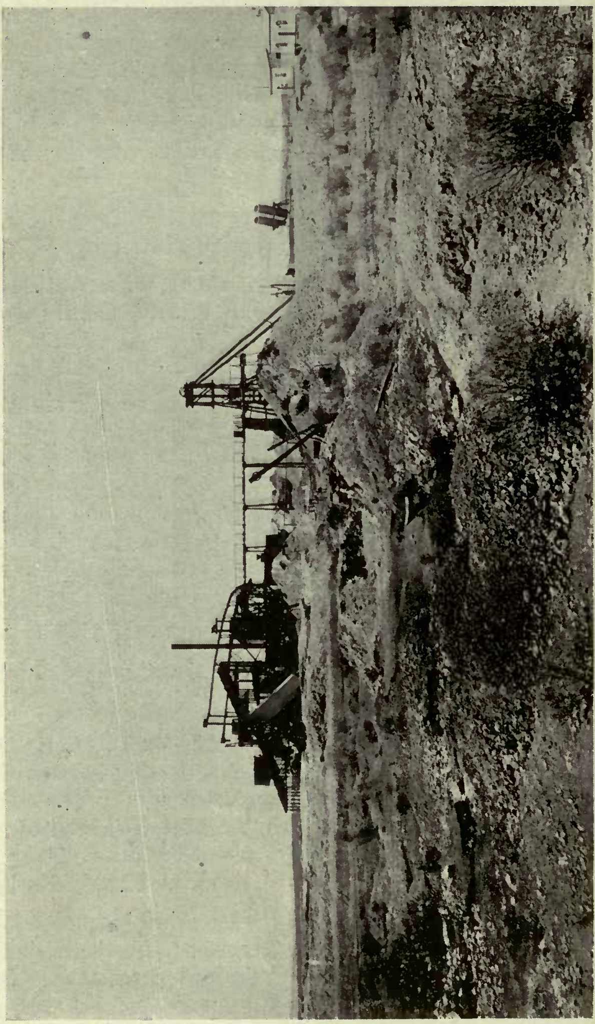


Fig. 40.

Photo: F. R. Feldtmann. Neg. F187.

Westralia United Main Shaft from North-West. Outcrop of lode marked by line of shafts.

The lode channel is very wide, and there appear in the cross section through the main shaft to be two main lines, apparently

Fig. 41.

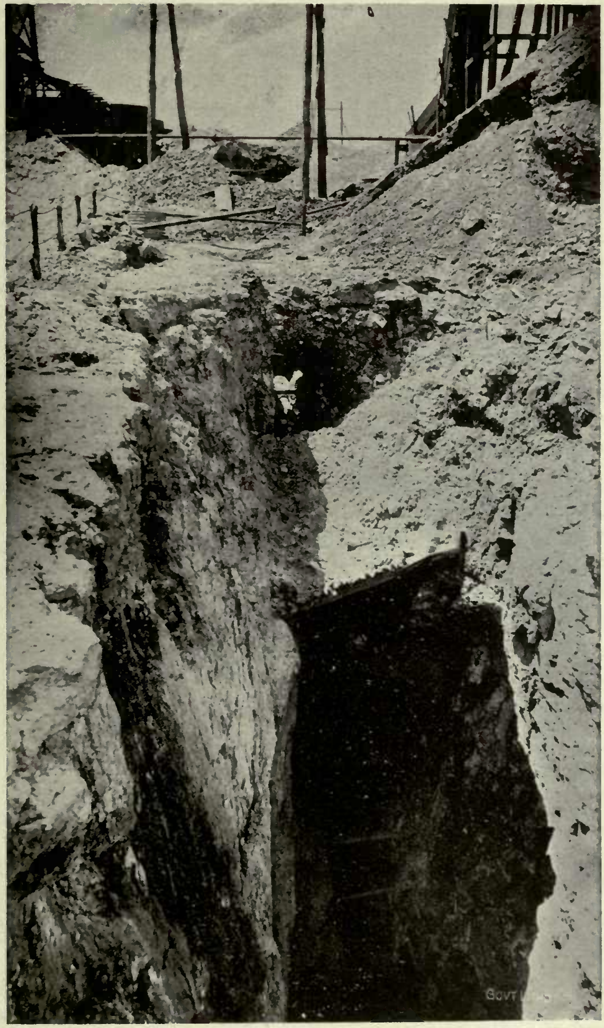


Photo: F. R. Feldtmann. Neg. F188.

Westralia United Open Cut from North.

joining to the north of the section, the western branch carrying the best values. At the 231ft. level the western branch seems to split going down. At the lower levels values have been generally disappointing, only one small lens of good ore being found at the 329ft. level.

The general structure and composition of the lode has already been discussed when dealing with the ore-deposits in general.

As this lode channel appears to be a particularly strong one, there seems to be no reason why other shoots of good ore should not be found. It should be mentioned that since this mine was examined another shoot of rich ore has been picked up in the northern workings by Messrs. McPherson and Rae, and two parcels, totalling 204 tons, are said to have given a return of £1,310 (including gold in residues), or an average of well over £6 to the ton.

EUCLID G.M.L. 4054E.

This is another of the Westralia United leases; it adjoins the south-eastern boundary of G.M.L. 4037E and covers parts of former G.M.Ls. 1094E and 1136E.

This lease is also partly in quartz-dolerite amphibolite, partly in fine-grained greenstone, the main lode running along the junction of the two rocks.

The lode is vertical in this lease; a small spur striking north and south, on the western side of the lode, joins the latter about 85 feet north of the "Euclid" shaft. This shaft has a depth of 144 feet and connects with the south drive at the 160ft. level from the main shaft in G.M.L. 4037E.

There were six other shafts on the lease at the time of my survey; the westernmost shaft, now inaccessible, being in typical quartz-dolerite amphibolite, it is unlikely that anything of value will be obtained therein.

RISING SUN G.M.L. 4039E.

This is the southernmost of the Westralia United leases. It is situated mainly between the Parkestown and Bulong Roads, and adjoins the Euclid and Bonnie Play leases. The western and larger portion of the ground was formerly covered by part of G.M.L. 1103E of the same name, the eastern portion forming part of G.M.L. 1038E, Hidden Treasure Consols.

Although there are a number of shafts on the lease, only the easternmost—the No. 4 shaft of the old Hidden Treasure Consols—has got below the oxidised zone, and that is in the spheroidal variety of the fine-grained amphibolite.

From the surrounding leases it is most likely that the western two-thirds of the lease are in dolerite-greenstone, and most of the remainder in fine-grained greenstone, a narrow strip along the north-eastern boundary being in the corresponding amphibolite. The southerly continuation of the Westralia United lode runs into the lease; near its southern end it seems to leave the boundary of the Older and Younger rocks and run into the fine-grained greenstone. The schistose formation, on which a little stoping has been done from the drive off the east cross-cut at the 96ft. level from the "Sunrise" shaft, is probably the continuation of the main lode. There are a number of minor formations on the lease, west of the main lode and roughly parallel to it. In one of these, cut in a costeen north-west of the above shaft there is a band of green, flinty quartz, probably fuchsitic. The rich patch recently discovered by Messrs. Regan and Rowe, is probably on a spur running north-west from the main lode, and dipping to the south-west; from this patch a parcel of 28 tons was treated for a return of £1,220.*

Returns for the Westralia United Goldfields, Ltd., leases are as follows:—

Name and Number of Lease.	Ore treated.	Gold therefrom.	Rate per ton.
	tons.	fine ozs.	fine ozs.
4037E, 4039E, 4054E, 4231E, 4368E, Westralia United Goldfields, Ltd.	1,719·77	504·80	0·29
4037E, 4039E, 4054E, 4231E, Rising Sun Leases	294·00	98·78	0·34
4039E, Rising Sun Lease	186·00	30·38	0·16
4037E, 4039E, 4054E, North End Mines, Ltd.	1,812·00	883·27	0·49
4037E, 4039E, 4054E, North End Gold Mines, Ltd.	5,876·00	2,425·03	0·41
4037E, 4039E, 4054E, 4231E. 4368E, Devon Consols S. Ex. Leases	8,269·14	2,712·76	0·33
4037E, 4039E, 4054E, Devon Consols S. Ex. Leases	2,251·00	1,400·94	0·62
	20,407·91	**8,055·96**	**0·39**

FAIR PLAY G.M.L. 4052E.

This lease lies to the south-east of the Bonnie Play and south of the Bulong Road, and together with G.M.L. 4063E, Fair Play Extended, is held by Messrs. Tregowarth Bros. and Quirk. It was formerly part of the Hidden Treasure Extended G.M.L. 1030E.

The western portion of the lease is partly in hornblendite, partly in talc-chlorite-carbonate rock, with actinolite-zoisite amphibolite at the western corner; the eastern portion is mainly in dolerite greenstone, with the talc rock again at the southern corner. The dolerite greenstone is found outcropping on a small rise near the centre of the lease.

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* *Vide* the *West Australian* of 10th March, 1915.

The main lode runs through the eastern portion of the lease about 115 feet west of the east corner; a number of small spurs apparently run from it in a north-westerly direction. There were only four shafts on the lease and some costeens near the southern end, most of the work on the lode having been done on the adjoining Fair Play Extended.

Two watercourses run through the north-western portion of the ground, joining before reaching the north-east boundary; a good deal of dryblowing has been done in their vicinity.

FAIR PLAY EXTENDED G.M.L. 4063E.

This lease is an irregularly-shaped block adjoining the Sunrise and Fair Play leases. The northern portion of the lease was formerly part of G.M.L. 1038E, Hidden Treasure Consols, while the southern portion was held as G.M.L. 1137E, Golden Gully North.

The extreme north-eastern portion of the lease is in fine-grained greenstone; this being seen in a long cross-cut at the 100ft. level, running from below the Bulong Road to the north-eastern boundary of the lease. The rock in this cross-cut was a good deal sheared—the junction between the Older and Younger Greenstones occurs in the western portion of the cross-cut, but the rocks in the vicinity were highly weathered, and it was almost impossible to determine its exact position. The north-western portion of the ground is in dolerite-greenstone, with the talc-rock to the south of this, while a narrow band of quartz-dolerite amphibolite runs along the eastern boundary; the latter is found east of the main shaft and close to a watercourse, which runs along the eastern boundary.

The main shaft (*vide* Fig. 16) is situated close to the north-eastern boundary of G.M.L. 4052E, and the outcrop of the lode runs about 12 feet east of the shaft. The general strike of the lode channel is nearly north and south, and the dip is variable, but in general steeply to the west. About 60 feet north of the shaft, at the surface, the lode splits, the western branch striking slightly west of north, the eastern about N.N.E. At, roughly, 100 feet N.E. of the shaft at the surface, and striking N.W.-S.E., is another sheared zone, coloured green by fuchsite; this sheared zone dips to the south-west at about 70°. It appears to have formed the hanging wall to the ore shoots, of which three have been worked between the surface and the 197ft. level. These all occurred along the eastern branch to the north of the green sheared zone, and south of another and smaller line of shearing roughly parallel to the first. This second shear plane apparently acting as the footwall of the shoot between the surface and the 107ft. level. Some specimen telluride ore was obtained in the stope on the third shoot below the 162ft. level.

Levels have been put in from the main shaft at depths of 107, 145, and 197 feet, and there are several intermediate levels. At the time of my visit the owners were driving on the lode south of the main shaft, at the bottom level. A little work has been done on the lode from a shaft in the southern portion of the lease. Levels have been put in at depths of 54 and 93 feet from this shaft. There is another N.W.-S.E. striking, fuchsitic formation at these workings, associated with a small albite-porphyrite dyke. The main lode seems to be represented here by a thin fuchsitic seam. Values up to about 15dwts. were obtained near its junction with the N.W.-S.E. striking formation.

From a close examination of the mine it would appear that patches of ore are found where the N.W.-S.E. formations join the main N.-S. line of lode. The richest shoots occurred in a highly shattered area, where, in addition to the cross sheared zones, the lode itself had split.

In the search for other shoots it might be as well to follow the line of junction between the two branches.

Returns for the Fair Play leases are given below:—

Name and Number of Lease.	Ore treated.	Gold therefrom.	Rate per ton.
	tons.	fine ozs.	fine ozs.
4052E, 4063E, 4319E*, Fair Play Leases	2,786·50	3,906·34†	1·40

* Now voided. † Includes 4·77 fine ozs. dollied and specimens.

ISABEL G.M.L. 983E (voided).

This lease was situated to the south-east of, and adjoining the Fair Play Extended. The ground is in fine-grained greenstone, with the exception of the narrow band of quartz dolerite derivatives on the western boundary. The narrow N.-S. formation mentioned in the description of the fine-grained greenstones runs roughly parallel to and between one and two chains east of the western boundary and the two main lines of lode, approximately parallel to each other, appear to turn slightly and run into it at, roughly, 100 and 330 feet, respectively, south of the northern boundary of the lease. There are other smaller probable lines of lode on the ground.

The main shaft is situated east of the main lodes near the centre of the lease; some long cross-cuts were put in east and west at the 177ft. level, nearly across the lease; these and all other workings, with the exception of the drive on the west lode at the 64ft. level, were inaccessible. Both lodes are approximately vertical. A fair amount of work has been done on both, but particularly on the western lode, which has been driven on for over 600 feet at the 177ft. level. Like most of the lodes in the fine-grained greenstones these lodes appear to have been patchy.

Returns for the lease are as follows:—

Name and Number of Lease.	Ore treated.	Gold therefrom.	Rate per ton.
	tons.	fine ozs.	fine ozs.
983E, Isabel	5,302·26	1,415·85*	0·27

* Includes 108·44 fine ozs. Dollied and specimens.

CRESWICK G.M.L. 4515E (voided).

This lease was situated south of the Isabel and was formerly G.M.L. 3991E, Hird's lease, and prior to that G.M.L. 547E, Mt. Ferrum. The western portion of the ground is in quartz-dolerite greenstone, the eastern in fine-grained greenstone.

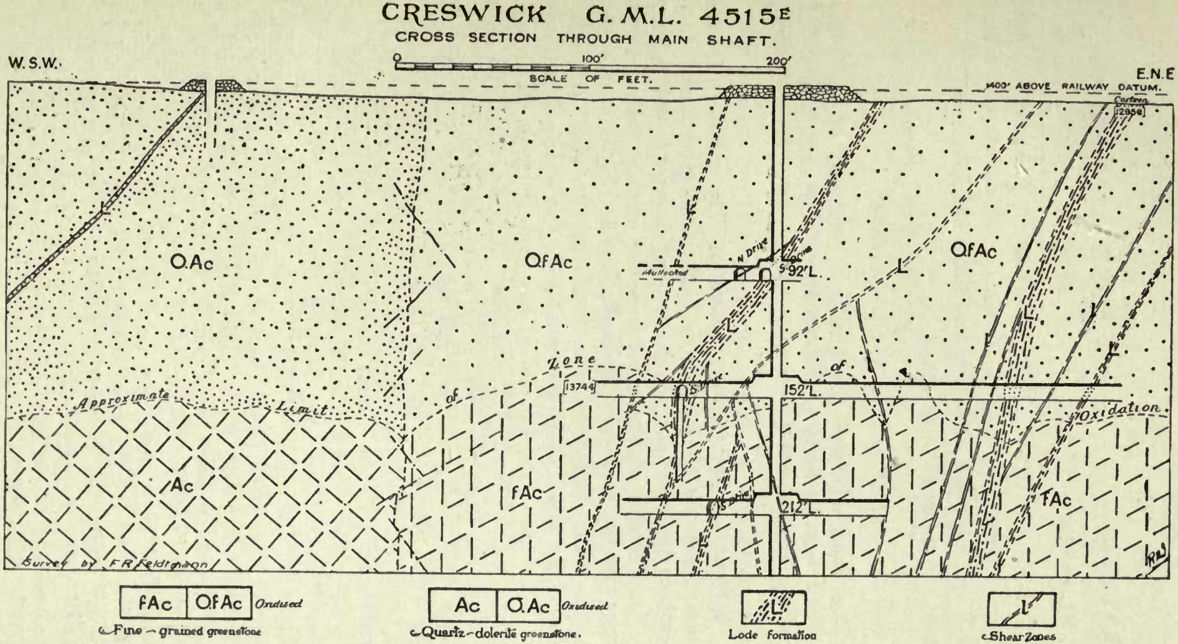
The previously mentioned N.-S. formation does not occur at the junction of the two rocks in this lease, but in the quartz-dolerite greenstone between 50 and 100 feet away from the junction at the surface, and dipping to the west at a little over 50. degrees, away from the junction. Close to the northern boundary of the lease another formation, striking N.W.-S.E., ran into the N.-S. lode from its eastern side, and a small shoot of ore, carrying fair values was struck at the junction; this was being worked by Messrs. Nelson Bros. at the time of my survey.

A fair amount of driving had been done on the N.-S. lode, at the 56 and 100ft. levels from a shaft 290ft. south-east of the north-west corner. A number of cross quartz veins were cut in these drives, on which some stoping had been done.

The old main shaft is situated near the centre of the lease in fine-grained greenstone; it is 366 feet in depth, but only the 92, 152, and 212ft. levels were accessible.

As may be seen on the cross section (Fig. 42), the fine-grained greenstone in the vicinity has been much sheared and shattered, but no really payable ore bodies appear to have been encountered. Small quantities of tellurides are said to have been obtained at the 212 and 352ft. levels.

Fig. 42.


CRESWICK G.M.L. 4515E
CROSS SECTION THROUGH MAIN SHAFT.
0
100'
200'
SCALE OF FEET.
W.S.W.
E.N.E
1400' ABOVE RAILWAY DATUM.
Cartem
[2856]
O.Ac
O.f.Ac
O.f.Ac
Ac
fAc
fAc
L
N Drive
Mullocked
S 92'L.
[1374]
152'L.
212'L.
S Drive
Approximate Limit of Zone of Oxidation
Survey by F.R. Feldtmann
fAc
O.f.Ac
Oxidised
Fine-grained greenstone
Ac
O.Ac
Oxidised
Quartz-dolerite greenstone.
Lode formation
Shear Zones

Returns are as follows:—

Name and Number of Lease.	Ore treated.	Gold therefrom.	Rate per ton.
	tons.	fine ozs.	fine ozs.
4515E, Creswick	1,404·86	261·40	0·19
3991E, Hird's Lease	1,152·47	1,217·63*	1·14
547E, Mt. Ferrum	20·00	21·91	1·10
	2,577·33	**1,500·94***	**0·58**

* Includes 42·85 fine ozs. dollied and specimens.

A.W.A. UNITED G.M.L. 4441E (voided).

This lease adjoined the southern boundary of the Creswick lease, and was formerly G.M.L. 4051E of the same name. Prior to that the ground was covered by G.M.L. 1490E, Mt. Ferrum.

The western and greater portion of the lease is in quartz-dolerite greenstone, the eastern in fine-grained greenstone. Close to the eastern boundary of the lease is a prominent laterite-capped hill—Mt. Ferrum, of which mention has already been made when dealing with the secondary impregnations in the zone of oxidation. The main N.-S. formation runs from the Creswick through the middle of the lease; it is here mainly in the quartz-dolerite greenstone, but at the southern end of the lease it leaves that rock and runs into the fine-grained greenstone. A little work was done on this formation from the 185ft. level from the main shaft, which is 400 feet deep, and is situated 200 feet north-east from the middle of the south-west boundary. A little work has been done on the same formation from the 93ft. level from a shaft close to the north-eastern boundary, but values seem to have been generally poor. The westernmost workings on the lease, on the continuation of the Hidden Secret South lode, have already been mentioned when dealing with that mine. This lease has been well prospected, long crosscuts having been put in west of the main shaft at the 185 and 400ft. levels and east of the main shaft at the 400ft. level, while east and west crosscuts were put in at the 92ft. level from No. 4 shaft on the northern slope of Mt. Ferrum. In addition three diamond-drill bores were put in from the 400ft. level, two from the western end of the west crosscut, the one dipping south-west, the other north-east, to vertical depths of 673 and 994 feet respectively below the surface level of the main shaft; the third from the eastern end of the east crosscut to a vertical depth of 902 feet below the same datum.

These leases formed part of the A.W.A. United leases, returns for which are given below:—

Name and Number of Lease.	Ore treated.	Gold therefrom.	Rate per ton.
	tons.	fine ozs.	fine ozs.
1101E, 4051E, 4070E, 4230E, 4275E, 4281E, 4302E, A.W.A. United Leases	59,640·50	14,017·42	0·24
3890E, 1101E, 1111E, Brown Hill Junction G.M. Co., N.L.	1,122·00	327·15	0·29
4200E, Mt. Ferrum Consols ..	32·00	4·35	0·14
4070E, Badra	30·00	10·15	0·34
	60,824·50	**14,359·07**	**0·24**

BROWNHILL JUNCTION G.M.L. 1101E and MT. FERRUM CONSOLS G.M.Ls. 4230E and 4275E (all voided). (Fig. 43 and Plates IV., V., and X.).

For convenience these three leases will be considered together; all belonged to the A.W.A. United group of leases. G.M.L. 1101E adjoined the south-eastern boundary of G.M.L. 4441E and the other two were situated south-east of the former. G.M.L. 4230E was formerly held as G.M.L. 4200E of the same name, and prior to that formed part of G.M.L. 3826E, Brown Hill Junction South, and at an earlier date G.M.L. 960E, Evening Star, while G.M.L. 4275E also formed parts of the last two leases and also G.M.L. 853E, Gem.

These leases are entirely in fine-grained greenstone. A fairly well defined and broad lode channel, in which there are three parallel lines of lode, runs through these leases; the middle line proved the best of the three, although a fair amount of work was also done on the western line, which apparently joins the middle line between the 199ft. and 300ft. levels in the section through the main shaft (*vide* Plate IV.). The rock in the vicinity of these two lines is highly brecciated. The main shaft, which is 400 feet deep, is situated on G.M.L. 1101E, and from it levels have been put in at depths of 98, 150, 199, and 300 feet, and drives north and south have been put in beyond the boundaries of the three leases at the 98ft. level and for nearly the same distance at the 199ft. level; these drives are on the middle lode, but a number of crosscuts were put in to the west lode, which was stoped out in places, while a great deal of stoping has been done on the middle lode between the surface and the 199ft. level. Some of these stopes are shown on the longitudinal section (Plate V.), but, unfortunately, nearly all are inaccessible, and their full extent could not be surveyed. In addition, the lodes have been worked in a series of large open-cuts; there has evidently been some impregnation of the surrounding country, from the width of rock taken out from these open-cuts.

A good deal has already been said about these lodes in that portion of the report dealing with the lodes in the fine-grained greenstones.

Fig. 43.

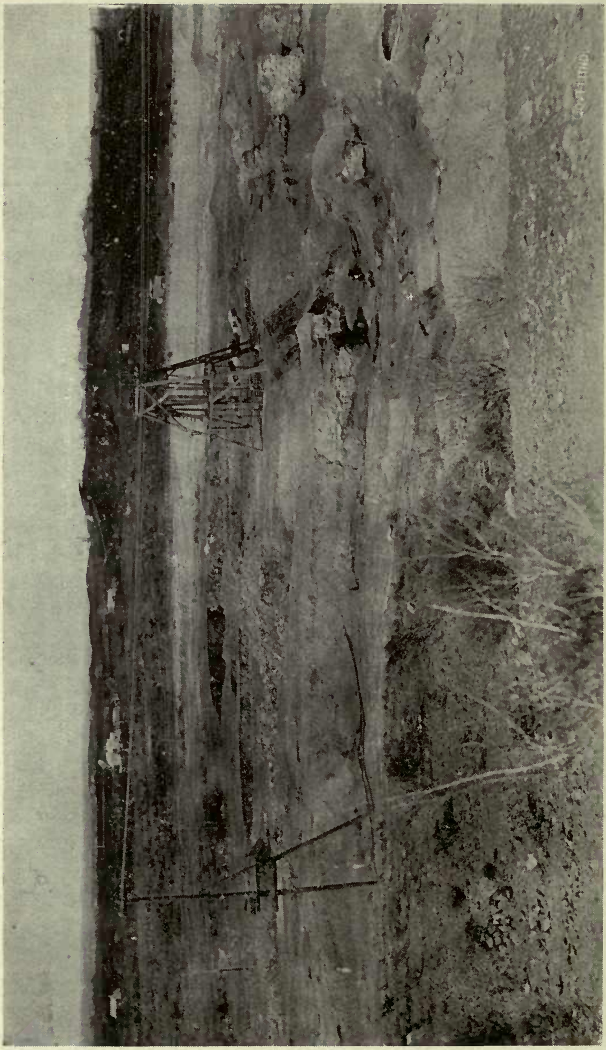


Photo: F. R. Feldtmann. Neg. F201.

Brown Hill Junction Main Shaft and Open Cuts from the North-West.

In addition to the mine workings, the country has been prospected by diamond drilling, two bores having been put in to the east and west from the 300ft. level—dipping at angles of 19 and 33 degrees—to total depths of 478 and 588 feet, respectively, below the surface level at the main shaft. Nothing of value, however, was struck in these bores.

The two northern leases have been well prospected, but little work, however, has been done on the most southerly of the three.

Badra G.M.L. 4070E (voided). This was another of the A.W.A. United leases, and was situated north-east of and adjoining G.M.L. 1101E. It was formerly part of G.M.L. 987E Etra Weenie. The ground is entirely in fine-grained greenstone.

There are three shafts on the ground, all inaccessible; the northernmost is said to be about 125 feet deep, and east and west crosscuts have been put in at the 90ft. level to the boundaries of the lease; the middle shaft is 210 feet deep, and crosscuts were driven to the boundaries at the 200ft. level; from the north-east crosscut at this level a diamond drill bore was put in at a dip of 30 degrees to a total depth of 379 feet below the surface level at the shaft.

Although several lines of lode run through the lease, no payable values have been encountered, and the ground has been too well prospected to permit of any hope for the discovery of payable orebodies in the future.

Returns for this lease are included in those for the A.W.A. United leases.

Mt. Lily G.M.L. 4404E (voided). This lease adjoined the Badra and Mt. Ferrum Consols leases, and was formerly held as G.M.L. 988E Clare Innis and part of G.M.L. 922E Herlichite, both belonging to the Brownhill Proprietary G.M. Co., Ltd.

A line of lode runs from the Badra into the northern portion of this ground, which is entirely in fine-grained greenstone; some costeening has been done on this formation and a shaft sunk on its eastern side—apparently without success. About half-way down the lease there is a long line of alluvial workings running right across the lease. As can be seen by the returns, a fair amount of gold was obtained from the Clare Innis, but from what workings, there is no record to show; most, however, probably came from this alluvial line. Another line of lode runs through the south-eastern portion of the ground, on which a shaft 300 feet deep and a number of shallow shafts have been sunk; old mine plans show drives on this lode at depths of 40 and 75 feet and a crosscut at 125 feet, but only a portion of the former level was accessible at the time of my survey. Judging by the returns, fair values were obtained in these upper levels, but there are no records as to the value of the lode at depth.

Returns for the ground are as follows:—

Name and Number of Lease.	Ore treated.	Gold therefrom.	Rate per ton.
	tons.	fine ozs.	fine ozs.
988E, Clare Innis	379·00	505·38	1·33
922E, Herlichite	280·50	173·23	0·62
	659·50	**680·61**	**1·03**

F. R. FELDTMANN,
FIELD GEOLOGIST.

27th March, 1916.

CONTRIBUTIONS

TO THE STUDY OF

THE GEOLOGY AND ORE DEPOSITS OF KALGOORLIE, EAST COOLGARDIE GOLDFIELD.

Part I.—Bulletin 42, **1912:—**

1. Geology of Kalgoorlie and Boulder. C. G. Gibson.
2. Composition and Internal Structure of the Kalgoorlie and Boulder Ores. E. S. Simpson.
3. Detailed Mineralogy of Kalgoorlie and Boulder. E. S. Simpson.
4. Surface and Underground Waters. E. S. Simpson.
5. Natural Gas in the Boulder Mines. E. S. Simpson.
6. The Constitution of the Native Tellurides. E. S. Simpson.
7. The Analyses of Telluride Minerals. E. S. Simpson.

Part II.—Bulletin 51, **1913:—**

8. The Geological Features of part of the Northernmost portion of the Kalgoorlie Auriferous Area. F. R. Feldtmann.
9. The Petrology of part of the Northernmost portion of the Kalgoorlie Field. R. A. Farquharson.

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